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VOL. VIII. NEW YORK, FEBRUARY, 1904. No. 12.

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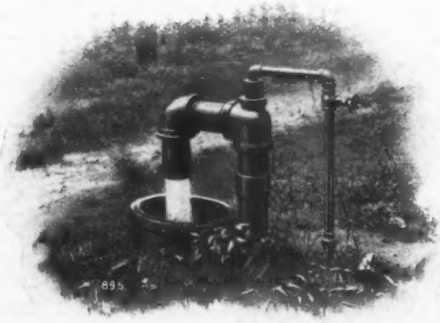

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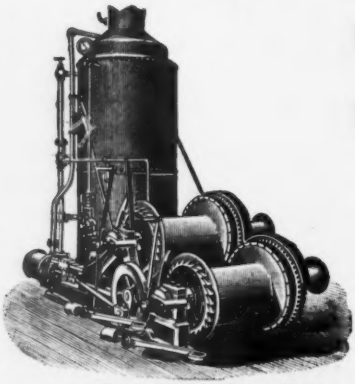

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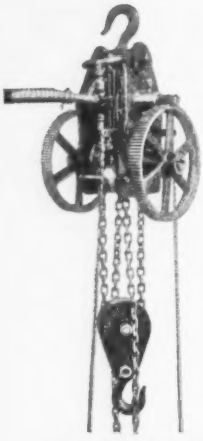

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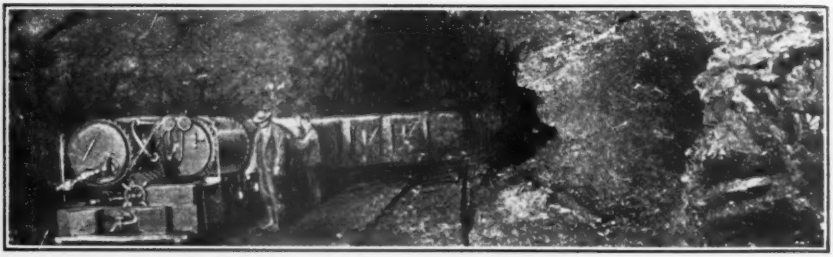

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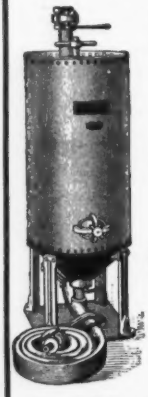

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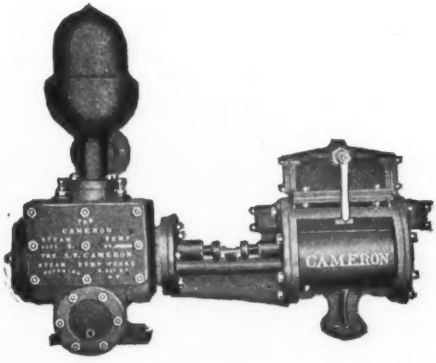

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Compressed Air Cleaning.

Some people have been horrified at the statement made by an official of the Pullman Company that the blankets in the sleeping cars of that company are washed but twice a year. If the cleaning of these blankets was confined to these two baths the public might have cause for complaint. As it is the blankets receive a cleaning at the end of every trip that is far more effective than would be the ordinary visit to the washtub. At the end of every journey they are removed from the car and "blown out" with a blast of air under high pressure.

The effectiveness of cleaning with air under compression is not appreciated by many. Experience, however, has demonstrated to those who have looked into the subject that it is of great value in securing proper sanitary conditions. As a matter of fact, the principle has been in successful use for hundreds of years. Who can name the first man or woman to hang a fabric out of doors to "air?" The fabric is freshened and purified as is possible by no other means. If these desirable results can be accomplished by the wind, which is really air under a slight pressure, how much more advantageous is a blast of air more powerful than the strongest hurricane, but under complete control?

In the case of "airing" by the wind the impurities are either carried away or oxidized as the air finds its way through the tiny spaces between the fibres or threads. A blast of air under heavy pressure accomplishes the same end, but in a much quicker time. Then, too, it possesses the advantages of a brush, and any material substances are brushed or blown away by power which is strong enough to carry particles several ounces in weight. The blast finds its way into the very fibres carrying the oxidizing process to a greater length and cleaning the cloth or fabric even more thoroughly than if it were given a bath in soapsuds. In fact, the powerful stream of air gives an "air scrubbing" which brushes, cleans and aerates the fabric, all in one process.

COMPRESSED AIR has described a number of methods of cleaning by compressed air, but they are dependent upon the same basic principle, that of passing a moving column of air around or through the articles to be cleaned, and as we have already noted, this principle is almost as old as man.

A Lesson of the Chicago Theatre Disaster.

A terrible disaster at the Iroquois Theatre, Chicago, has drawn public attention to every variety of safety appliances which will help to prevent a repetition of Chicago's awful experience.

Many suggestions have been made, some of which are excellent and will, doubtless, be adopted. Among these various methods it is not surprising that compressed air is

included. A novel idea, however, in which that method of power transmission figures is advanced by a correspondent of the New York *Sun*, who, over the anonymous signature of "An Actor," writes as follows:

"*To the Editor of The Sun:* SIR—There is a simple device in use upon every railway in this country which could be adopted for use in theatres and public halls in such a way as to preclude the possibility of locked doors and non-falling fireproof curtains in times of emergency. This is the air brake, operated from a central station and controlled by levers in various parts of each car in every train. By a few simple changes in this mechanism it could be arranged so that a compressing or exhausting engine in the machine room of the theatre would not only unlock but force open every door in the auditorium of any theatre. At the same time the pneumatic power could force the asbestos curtain down—not merely release it for a fall, but actually force it to the stage floor; and while this was being done another division of the mechanism could turn up every exit light and any number of emergency lanterns that might be provided.

"Such a machine could be controlled by buttons or cords in the auditorium, one at every seat, or one at every row of seats. Any spectator could, by pressing a button or by pulling a cord, at one act lower the fireproof curtain, open every exit and turn on every light in the house, regardless of what was going forward on the stage. By the use of such machines one of the principal causes of panic and its terrible consequences would be averted, for nothing is more terrifying to an audience than the darkness of a theatre auditorium in time of peril."

If any system to accomplish automatically all the desired ends at the same time is adopted, there is no reason why compressed air cannot play a most important part. While this suggestion to utilize the air brake of the steam railway is feasible, a more simple method similar to that used to close the bulkhead doors on a warship would be preferable. Instead of closing the doors the same principle could be applied to open the exits and to lower the asbestos curtain, adjust the skylights and whatever else was necessary in case of fire. This system could be easily controlled at various points behind the scenes and in the auditorium.

There is common sense in "An Actor's" suggestion, although the device would require important changes before it was adapted to the very different conditions. As long as human agency is depended on in case of emergency there is bound to come a time when a misunderstanding or a sudden unexplainable fear will change the best laid plans. Of all the methods of power transmission there is none more reliable than the air itself. Compressed air's advantage in that direction has long been recognized and for that reason it is used to accomplish certain results where failure would mean serious, if not fatal disaster. There is no reason why it cannot be put to practical use in theatres to prevent another such catastrophe.

Sawing by Compressed Air.

Considerable attention has been drawn to a new invention recently appearing in the west which introduces the use of compressed air for operating a saw. This appliance is known as the Redfield pneumatic engine and frame and is built by the Ashland Iron Works, of Ashland, Ore. This is adapted for operating drag saws for cutting logs, cord wood, heavy timber and for general use in timber and log camps, displacing hand power equipment, now generally used. Compressed air to operate the engine and saw can be obtained by using a steam, belt, gasoline or electric driven compressor or by an ordinary locomotive air pump attached to the boiler of any logging or portable engine.

The pneumatic engine is capable of making from 125 to 150 strokes per minute, depending on the pressure of air used. At 60 pounds pressure it will develop 2½ horse-power. The engine weighs 50 pounds, being constructed almost entirely of brass and steel tubing. It is claimed for the valve motion, which is of an entirely new design, that it has no complicated valves or parts to get out of order and that it is very simple and easy of adjustment. The frame is made of machine steel and wood and though light in weight is strong and durable.

The makers declare that one man with one of these machines can easily cut 10 cords of 2-foot wood per day, or 50,000 feet in logs, reducing the present labor expense at least 50 per cent. The first machine constructed was given a trial in the woods by the McCloud River Lumber Company, of McCloud, Cal. It proved so satisfactory after a thorough test that an order for a number was placed.

The accompanying illustrations serve to show the constructive details of a 2½ by 30-inch pneumatic engine and 16-inch frame. Figure No. 1 shows a vertical longitudinal section on centre line of engine, and Figure No. 2 is a general drawing of the engine and frame complete.

THE PNEUMATIC SAW AT WORK.

Referring to Figure No. 1.

It will be seen that the engine consists of a cylinder *I* made of solid drawn brass tubing, in which is the piston and tubular piston rod *II*; two brass cylinder heads *K* and *K1* with their respective valve chambers, ports and passages; a tubular valve *H* provided at the rear end

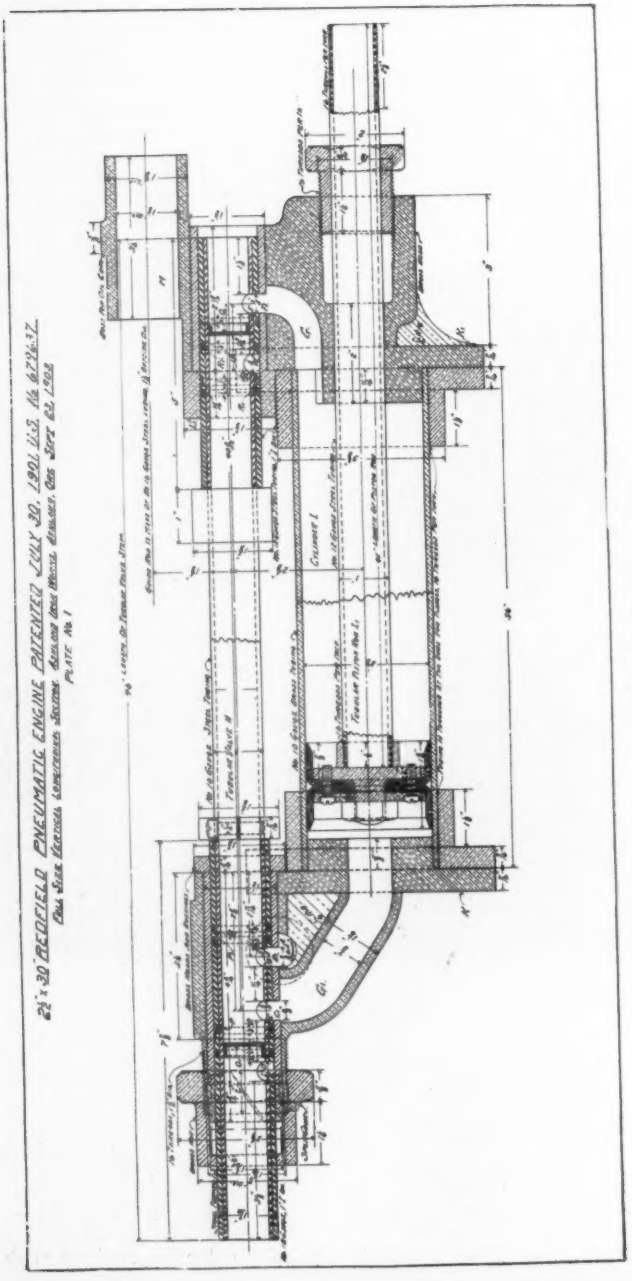

24' x 30' REDFIELD PNEUMATIC ENGINE PATENTED JULY 30, 1901, U.S. No. 679632
PLATE No. 1

FIGURE NO. 1.

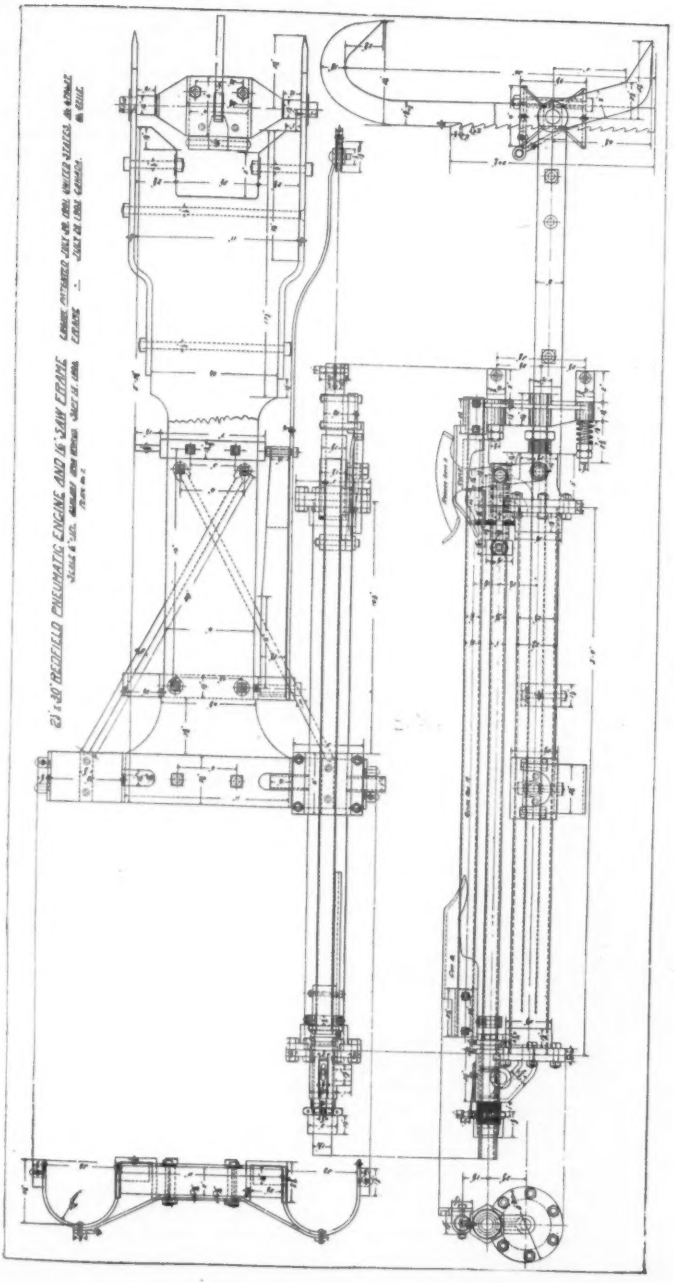


FIGURE NO. 2.

with the ports *B*, *C* and *D*, with a dividing wall or bridge *O* between ports *C* and *D*, and two sets of snap rings *P* and *Pl*, and also provided at the forward end with the ports *E* and *F*, and the bridge *Q* and the snap rings *R* and *R*; the guide *M* is a part of the forward cylinder head, and serves as a guide for a tubular guide rod which is not shown on this plate, but which is connected with the crosshead on the main piston rod and actuates the tubular valve and also serves to keep the crosshead and attached saw in a vertical position.

Referring to Figure No. 2.

On the front cylinder head is a rocker arm *A* which is connected to the tubular valve by means of the connecting rod shown on drawing, and as the piston moves backward and forward the guide rod *R* on which is fastened the cams *B* and *Bl* also moves backward and forward being attached to the crosshead, and as the piston approaches either end of its stroke the cams *B* and *Bl* alternately come in contact with the rocker arm *A* causing it to oscillate and transmit its motion to the tubular valve which controls the distribution of the air to the cylinder.

Referring again to Figure No. 1 the modus operandi is as follows:

The piston being at the beginning of its forward stroke, the valve will be in the position shown on the drawing, and the air which is conveyed to the cylinder through a hose from the supply reservoir, enters the back cylinder head *K* through the air supply chamber *A*, thence through port *Bl* of the valve chamber bushing and port *B* of the valve to the inside of the tubular valve *H* and passes through port *C* and *Cl* and passage *G* to the cylinder. The piston now moves forward and the forward end is open to the atmosphere through passage *G* and port *Fl* and *F*. As the piston approaches the end of its forward stroke the cam *Bl* shown on Plate No. 2 comes in contact with the rocker arm *A*, moving it and the tubular valve ahead, bringing port *E* of the tubular valve *H* in communication with port *Fl* of the valve chamber bushing *Ll*, also port *C* of the rear end in communication with port *Bl* and port *D* in communication with port *Gl*. Air is now supplied to the forward end of the cylinder through ports *Bl* and *C* thence through the tubular valve *H*, the ports *E* and *Fl* and the passage *G*. As the port *D* is in communication with port *Gl*, the exhaust takes place through passage *Gl*, ports *Cl* and *D*, and out through the open end of the tubular valve *H*.

The function of the bridges *O* and *Q* and the snap rings *P* and *Pl* and *R* and *Rl* will be readily understood and needs no further explanation. The split cone *J* around the tubular valve *H* on the rear head is adjusted by means of the brass nut shown on the drawing and serves the purpose of causing an even extension to the tubular valve, thereby avoiding any possible movement of the tubular valve in the way of slipping and to prevent any movement of the valve except at the proper time.

The Stanley Heading Machine.

I have read an abstract of the paper by Mr. F. C. Swallow, of the Nuneaton Colliery in Warwickshire, England, which was read before the Institution of Mining Engineers, September 2, 1903, and subsequently published in the *Colliery Guardian*, September 11, 1903. The abstract is very interesting and brings out a number of features in connection with the application of the machine as described in the paper.

Let it be understood that the Nuneaton Colliery, which is located near the town of Nuneaton, is owned and operated by Mr. Stanley, who is also the owner and proprietor of the Stanley heading machine. It would seem natural, therefore, that in getting data for a paper of this kind, he would gather it from machines working under the most favorable conditions. But for the benefit of the public it might have been better had he given general results, taken from all of the machines during the period of seven weeks.

From a table recording the coal cut per shift by one annular groove machine it shows a distance of 1,169 running feet in seven weeks with one machine, cutting out a single heading 5½ feet in diameter. If this machine worked one eight-hour shift every 24 hours, it aggregates 42 working shifts, and averages 27.88 running feet per shift, and all of the coal coming out of the heading was loaded on a single track, using but

one car at a time, and, we presume, was mostly handled by one man. 27.88 running feet represents an output of about 20 tons of coal per shift, and it would appear that this amount of coal will require a good man to handle and work it from a point where it is dislodged by the cutter head, back past the heading machine, and finally into the car.

It might be well to mention that the mere shoveling of the coal back and into the car is not all the work that is to be done, and for the benefit of the readers of COMPRESSED AIR, it will be well to consider a few of the details in connection with the application of the machine and the work connected with it. The machine itself is very large, long and heavy, and when set up and ready for operation takes up most of the space in the circular heading, and leaves but little room for a man to pass by and to attend to his work of getting the coal back past the machine. This in itself requires a great deal of manual labor. But this is not all. The cutter head makes an annular's groove, say three inches wide, leaving a very heavy core in the center, which, if it does not fall of its own weight, must be picked down with a hand pick by the helper. This work, together with that of getting the coal back past the machine represents an enormous amount of labor, and we are at a loss to understand how one man can accomplish so much.

The cutter head on the machine is carried forward by a central column with a screw feed, and is so constructed as to enable it to cut the groove three feet forward without stopping the machine. At this point, however, all of the coal must be cleaned up and passed back behind the machine, and the cutter head drawn back a distance of three feet, and the whole machine moved forward against the face of the heading, when the same operation is repeated, so that in a distance of 27 feet, the machine has got to be shifted forward nine times, and anchored or made substantially fast and tight at each move so that it will stand up to the work ahead of it without working backwards.

I have had some little experience with the Stanley heading machine and know something of its application and limitation. I know that the machine is rapid when being operated under favorable conditions. But where the conditions are not in every way favorable, it is a very slow and expensive machine to use. In order to use this machine to the best advantage and economy, the coal bed in which it is operated should be thicker than the cutter head is high, so that all of the cutting would be done in the coal, and at the same time leaving a coal roof. If the coal is harder at the top than it is at the bottom, the machine has a tendency to work downward, and if it is harder in the bottom than in the top, it then has a tendency to climb up, and thus gets out of line with the heading. When once out of line, there is hardly any way of getting it back into position, except by digging the machine out, leveling up the bottom and again starting it in line. Such a condition often requires two or three men for a day or two to get the machine out and lined up and ready to start anew.

So it would appear that the Stanley machine, while it may have done remarkably well in Mr. Stanley's mine in Nuneaton, cannot do so under all conditions. It is a machine which can only be applied successfully under ideal conditions, as is virtually brought out in Mr. Swallow's paper; for he states that if the heading was to be "driven with a Stanley heading machine 5½ feet in diameter, it should be driven under the spire coal, which forms a very tough roof, and there is thus about 22 inches of coal left undisturbed."

I do not wish the reader to infer that I am in any way prejudiced against the Stanley or any other machine which can be used in any way to advantage in developing or operating coal mines, and I feel certain that the Stanley header has been doing good work in England, especially where the conditions are favorable to its use, and where rapid development is so essential. I believe it is conceded that this machine is better adapted to driving air courses than haulage ways, as by reason of the circular heading, which is only 5½ feet in diameter, it is not large enough to be used as a haulage way.

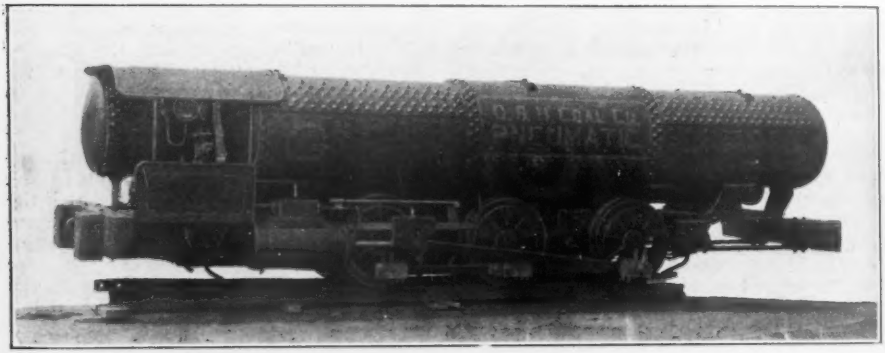
We have tried this machine in a number of places in the United States, and it has been found that the conditions necessary for its successful use are so rare that it has fallen entirely into disuse.

L. J. DAFT.

Compressed Air Locomotives, Built by the American Locomotive Company.

A solution of the problem of mine haulage has been attempted variously by animal power, compressed air, electricity and steam. Of these methods, compressed air is easily first from the standpoint of convenience, safety and economy; convenience in always being ready for work when the air supply is adequate, safe in places that would bar the steam or electric engine, owing to danger from fire or explosion from mine gases, and economical from the fact that there is no loss due to condensation as with steam, nor leakage as with electricity; the pressure when once stored, suffering no loss of energy, until having passed through the cylinders of the engine. The passing of animal power in mines is rapidly taking place, although mules are used in combination with air to some extent where air has not been provided to cover the needs of the entire plant. Under such conditions, the air motor is not seen at its best, but the compressor duty is correspondingly low. An additional advantage is had by the re-heating of air before admission to cylinders, but this refinement is not regarded with favor for mine work in general.

The American Locomotive Company has long made a specialty of air locomotives for use in and about mines, ore plants and furnaces. They are built of different sizes and types, of which two representative machines are illustrated herewith. The six-wheel engine has two storage tanks, thirty inches in diameter, in which is carried 170 cubic feet of air at 600 pounds pressure per square inch. Under these larger tanks and connecting with them by a reducing valve is an auxiliary tank ten inches in diameter which carries a working pressure of 140 pounds per square inch. This pressure is used in plain slide valve cylinders, and is controlled by a shifting link motion. In fact, the engines are identical with those in which steam is used. To overcome refrigeration at the exhaust, the exhaust openings, which are between the frame (as there are no exhaust pipes), are contracted so as to furnish just enough heat to keep expanded air above freezing point, which it does without material back pressure in the cylinders. This motor is designed for heavy work, and will exert a drawbar pull of 6,000 pounds. This is equivalent under ordinary conditions of average mine track to a hauling capacity on level, of 318 net tons of 2,000 pounds. On a grade of 3 per cent., 60 net tons, and on a grade of 6 per cent., 28 net tons. The following general description will be of interest in connection with half tones:

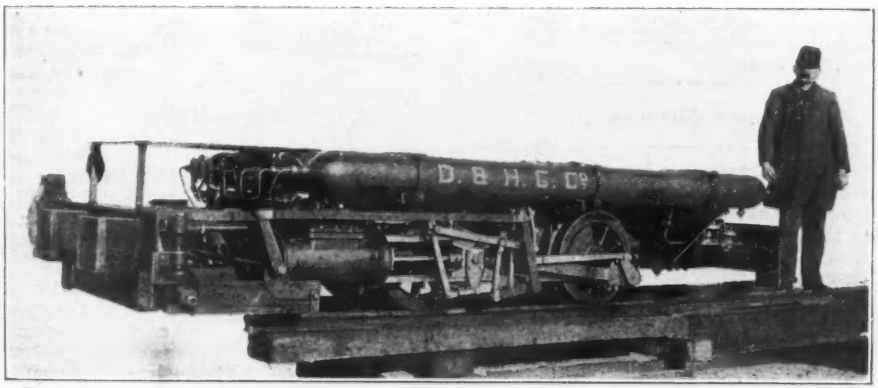


GENERAL DIMENSIONS.

Of 6-wheel Air Locomotive.

Diameter of cylinders..	9 in.
Stroke of piston.....	16 in.
Diameter of driving wheels	26 in.
Total wheel base.....	7 ft.
Total length over bumpers	21 ft. 10¾ in.
Total height.....	5 ft. 1 in.
Total width.....	5 ft. 9 in.
Storage capacity for air	170 cu. ft.
Storage pressure.....600 lbs. per sq. in.	
Auxiliary and working pressure .....140 lbs. per sq. in.	
Weight	30,600 lbs.

storage capacity of air. This construction permits of the reduction of height necessary in restricted spaces, such as chambers and inside workings of low head way. The storage capacity of the tubes is forty cubic feet of air at 700 pounds pressure per square inch. As in the case of the large machines there is a small auxiliary tank which is connected to the tube storage system by reducing valve which supplies to the cylinders a working pressure of 125 pounds per square inch. The valves are controlled by a Walschaert valve gear which is substituted for the link motion for want of room under the machine, and because of the accessibility of its parts for inspection. These small ma-



A smaller engine of the double tank type is made for use on sharp curves where the above described engine is not available. This machine is carried on four wheels, having a wheel base of 5 feet 3 inches. The cylinders are 9 by 14 inches, wheels 26 inches in diameter, the tanks 27 inches in diameter and the weight 22,100 pounds. The tractive power of this machine is 5,000 pounds. Capacity in net tons on level equals 267. On 3 per cent. grade, 53 tons, and on 6 per cent. grade, 25 tons.

The smallest motor is also of the 4-wheel design, but has ten-inch Mannesmann seamless steel tubes to furnish

chines, iike the mules, go down in a mine practically for life, and any scheme that facilitates repairs in case of break down, is of first importance. They are good for drawbar effort of 3,000 pounds, which gives a capacity on levels of 160 net tons; on 3 per cent. grade, 32 net tons, and on 6 per cent grade, 15 net tons. The height and width are such as make these little motors available for use in situations where it is impossible to use animal power. The accompanying half tone and description convey a clear idea of the low workings these machines can be used in.

GENERAL DIMENSIONS.

Of small 4-wheel Air Locomotive.

Diameter of cylinders..	7 in.
Stroke of piston.....	14 in.
Diameter of driving wheels	24 in.
Total wheel base.....	4 ft. 3 in.
Total length.....	12 ft. 3 in.
Total height.....	2 ft. 11 in.
Total width.....	6 ft. 4 in.
Storage capacity for air	40 cu. ft.
Storage pressure.....	700 lbs. per sq.in.
Auxiliary and working pressure	125 lbs. per sq. in.
Weight	13,100 lbs.

The American Locomotive Company has furnished many of these compressed air locomotives to the Pennsylvania Coal Company, the Delaware & Hudson Company and others, where results of the most satisfactory character are being obtained by their use.

Air Compressors.*

As compressed air is coming into general use, it is essential that steam engineers should have a general knowledge of the principles governing its compression, application and lubrication of the air-compressing cylinders.

The use of compressed air is not the result of recent discovery; rather than this we can trace its use as far back as two thousand years before the Christian era, when it was used in connection with forges and blast furnaces for reduction of metals and forging of same.

In 1653, we find the first record of compressed air being used as a transmitter of power. At that time Denys Papin developed the use of water for compressing air and forcing it to a distance to perform work.

From the time of the experiment mentioned to the present patents too numerous to mention have been issued for devices to be used in connection with compressing air. In 1829, a patent was issued to Wm. Mann on a compound or two-stage compressor, which was probably the first of its kind. With this machine came the first suggestion of water-cooling or inter-cooling, which properly claimed not only to effect greater economy, but also to decrease strain on the machine as well as to admit of lighter construction of compressors.

Further progress along this line was made about 1873 by means of water jets or sprays for inter-cooling, leading to the present-day methods of water-jacketing and inter-cooling systems, which have reached a degree of perfection that admits of but little further improvement except in details of construction.

The precise limit of the compressibility of air at ordinary temperature is as yet an unknown quantity. It has been compressed to 14,000 pounds per square inch in experiments for blasting rock, and there seems to be no reason to doubt the assertion that any pressure may be obtained within the limit of safety in strength of metals to hold the pressure.

Even in these days of investigation and enlightenment we find many intelligent engineers who will not consider the claims of compressed air as a means of power transmission, because of a belief that its use means a great loss in economy. A little impartial investigation will, however, show that its value is unique in that it is always and instantly ready to do work at full capacity, and that it can be easily controlled at any required pressure.

The compression of air from a lower to a higher pressure results in the conversion of energy into heat; the temperature increases with pressure, but not in the same ratio. Tables have been published giving the rise in temperature for various pressures, but in actual practice these temperatures are not attained, for the reason that in the economical operation of air compressors it is imperative that temperatures be kept as low as possible. In order to do this the heads and barrels of compressors are provided with jackets through which water circulates to absorb the heat of compression.

Where the air is compressed in more than one cylinder the temperature is still further reduced by passing it through inter-coolers on its way from one cylinder to the other.

These inter-coolers consist of chambers or cylinders of cast iron, connecting the discharge of one compressing cylinder to the inlet of the other. They contain a number of small tubes through

*Paper read by M. E. Stover before Ohio, No. 88, National Association of Stationary Engineers, at Columbus, Nov. 5, 1903.

which the air passes, and over which water is kept circulating.

With the two-stage type of compressor the air is compressed to from 30 to 40 pounds pressure in the first cylinder, and then passes to the second cylinder, where its pressure is raised to from 100 to 150 pounds. Machines are constructed of the three and four stage type for pressures from 600 to 4,000 pounds.

In a single-cylinder machine taking air at 60 degrees F. and compressing it to 100 pounds, the air at discharge will be, theoretically, 485 degrees F.; but the cooling water of the jackets will absorb much of the heat and lower the temperature considerably, depending on the speed of the compressor and temperature and amount of cooling water.

In a two-stage machine with compression to 30 or 40 pounds, the discharge from the first cylinder will be from 200 to 250 degrees F. In passing through the inter-cooler its temperature will be reduced to 80 or 90 degrees F.; the second cylinder raises the pressure to 100 or 150 pounds, with a final temperature of from 200 to 275 degrees F. The same process is followed with the three or four stage machines.

In lubricating the interior of an air compressor cylinder conditions will be found different from those existing in a steam engine cylinder. In the former the heat is dry, while in the latter moisture is always present. Moisture has a tendency to wash oil from the surfaces, whereas with a dry heat the oil adheres to the surfaces better, with the result that a given amount of oil will give better and longer service in the air cylinder than in a steam engine cylinder, both being of equal size.

Owing to the intense heat, the oil used in an air-compressing cylinder must be of such a nature that it will not deposit a coating of carbon or burnt oil in and around the discharge valves of the compressor. If of too low flash test, the oil, on reaching the interior of compressor, will vaporize and pass off with the air without affording any lubrication to the wearing surfaces. If the oil is too dense, or is compounded with animal or vegetable oils, it will have a tendency to adhere to the discharge valves and passages, and will gradually change to a hard, brittle crust or layer of carbon, which in time will completely choke up the passages and render the valves inoperative.

It has been found by numerous experiments that, where the temperature of the air reaches 350 degrees F. to 400 degrees F., a pure petroleum oil of from 500 degrees to 530 degrees flash test and of medium viscosity, will give the most satisfactory results. When the temperature does not rise to over 300 degrees F., a more limpid oil and of lower flash test can be used, say of 400 degrees to 425 degrees flash test.

It is very important that the air suction or intake pipe be so placed that air can be had that is free from dust and dirt, as any such substance will adhere to the oily surfaces of the compressor and in time interfere with the proper working of the valves. Complaint is often made about the quality of oil, when the real trouble is due to dirty air.

Most cases of complaint about the formation of coke or carbon deposits come from users of single-cylinder compressors of small size and of the spring valve type. These machines are often worked above rated capacity; the air temperature goes above 400 degrees F., and the tendency of the attendants is to use too much oil, in which case the surplus oil gathers around the valves and passages and causes the trouble. For a cylinder 12 inches in diameter or less, a half a gill of oil per ten or twelve hours should be sufficient. If the valves are mechanically operated a slightly greater amount may be necessary.

The Concrete Dry-Dock at Kiel, Germany: Subaqueous Construction by Floating Pneumatic Caisson.

The docking facilities of the German navy at the government yard at Kiel, Germany, have quite recently been extended by the construction of a very large fixed dry-dock. The dock, which is double (having two dock chambers side by side), lies for the greater part of its length in open water, and consists of a solid concrete basin resting upon the clay subsoil of the harbor bottom without special foundation. The peculiarities of the location made the work of construction an exceedingly difficult problem; indeed, all ordinary methods were inapplicable or excessively costly. A wholly new plan of working was there-

fore devised, and with it the work has been successfully carried to virtual completion. The central feature of the method is the use of what is in effect a huge diving-bell—a great rectangular pneumatic caisson suspended over the work by a supporting framework carried on pontoons. This caisson formed a pneumatic working chamber in which the

far as is necessary for a full understanding of the work.

CONDITIONS AFFECTING THE WORK.—The dock is intended to accommodate in either chamber the largest vessel of the German navy, at all stages of water and even under conditions when such a vessel exceeds its normal draft. as in case of injury. The large amount

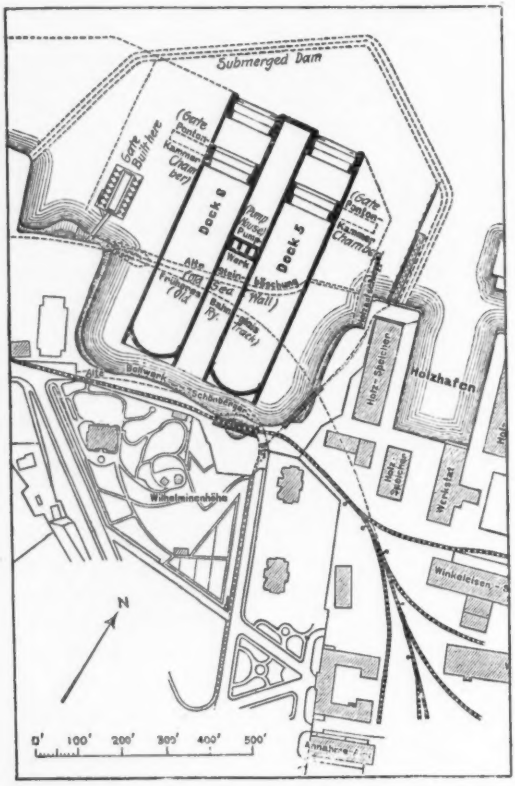


FIG. 1—LOCATION PLAN OF NEW CONCRETE DRY-DOCK AT KIEL, GERMANY.

concreting was carried on under air pressure, the site having been previously prepared for the concreting by dredging. The work is sufficiently remarkable to merit close study, and to this end we give herewith a description and drawings of the construction plant and an outline of the method of working. The dry-dock itself we describe only as

of dredging which would be required for a floating dry-dock in Kiel harbor, and the greater operating cost, rendered a floating dock inadvisable. Local conditions restricted a fixed dock to the site indicated in Fig. 1, which represents a ground plan of the location adopted. A bluff rising some distance back of the old shore line limited the inshore length

of the docks, and the remaining portion therefore projects out into the harbor.

There is practically no tide at Kiel, but considerable variations of water level are caused by continued winds; variations up to 3 feet above and below normal are not rare. The normal depth of water at the outer end of the dock site is 25 to 40 feet. The subsoil consists of sand and gravel, bearing clay in the upper layers; farther down is a stratum of compact sand overlying good blue clay. Over the sand and gravel is a considerable depth of very soft mud, which forms the immediate harbor bottom. The depth of satisfactory foundation strata—sand and clay—is from 40 to 70 feet below water level, at the outer end of the site; the overlying strata are in general strongly water-bearing. Under these conditions any method of cofferdam construction seemed out of the question. Recourse was therefore had to the pneumatic process, using the suspended caisson to be described farther on.

The dock has no special foundation, but rests directly on the clay subsoil. The dimensions of each of the two dock chambers are: Length inside, 574 feet (175 m.); top width of entrance, 98.4 feet (30 m.); depth, 36.9 feet (11.25 m.) at the entrance, and 6 inches less in the chamber itself. The length of 574 feet is defined by a gate notch close to the extreme outer end of the dock. Some distance inside of this is another gate notch, giving a length of 459 feet, and this is the one intended for regular use. The gate is a horizontally sliding gate, working in a gate chamber extending out from the dock, as indicated in Fig. 1. This chamber is at the 459-foot gate notch, and to use the second, or 574-foot notch, it is necessary to float the gate (constructed as a caisson gate) and transfer it to the outer notch. It should be said that the actual end of the dock constitutes still a third gate notch, for purposes of construction only.

The two dock chambers, each a complete dry-dock in itself, lie side by side, separated by a clear distance of 75 feet, corresponding to 209.9 feet between the longitudinal axes of the two chambers. At the front, or outer end, of the docks this space is closed off by a wall connecting the side walls of the two docks and carried up to the same height. About in the middle of the length of the docks, and in the space between them, is the single pump house serving both dock chambers. The rear, or landward, wall

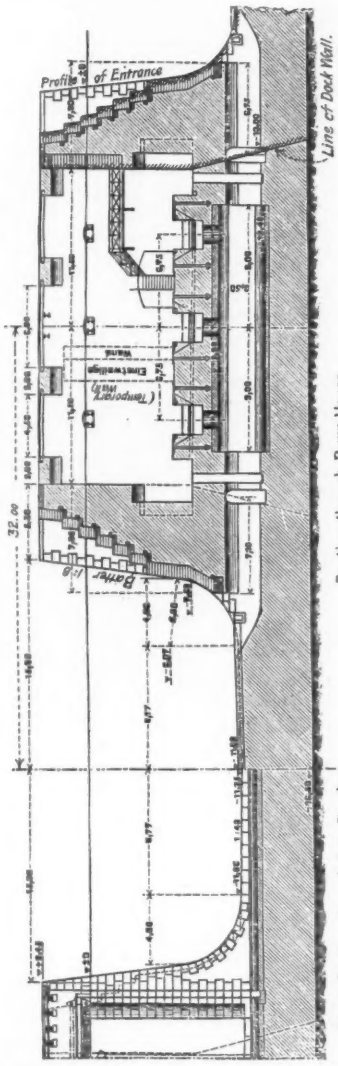


FIG. 2—CROSS SECTIONS THROUGH GATE-CHAMBER AND PUMP-HOUSE.

of each dock chamber is arched outward in a vertical plane, and the side walls are carried a short distance beyond this arch to facilitate a future landward extension of the dock.

The principal features of the design of the docks will be clear from the preceding, together with Fig. 2, showing a part cross-section through the gate chamber of one dock and the pump house. The flat bottom and the slight splay of the sides should be noted. The material is concrete throughout, except that the gate notches, the entrance, and the bottom of the dock chamber are faced with granite, while the side walls are faced with brick and stepped with basalt. The great thickness of the bottom of the dock, 17 feet, as shown in Fig. 2, was thought necessary on account of the existence of springs in the strata on which the dock rests.

METHOD AND COURSE OF CONSTRUCTION.—In Fig. 1 is shown a broken line indicating the original shore line at the site, protected by a stone sea wall; the site landward of this wall could be excavated largely in the dry. The remainder of the space covered by the dock had to be excavated down to the solid foundation stratum by dredging. Previous to the dredging, however, it was necessary to protect the space to be excavated from continued inflow of the soft mud which covered the bottom, the mud being sufficiently liquid to flow in toward any depression which might be dredged in it. For this purpose a submarine dam or earth embankment was constructed on the line indicated in Fig. 1, completely enclosing the building site. It was formed simply by dumping earth from scows over the desired location of the dam. The mud was soft enough to allow the earth to penetrate through it under the weight of the superincumbent layers, so as to finally reach down to the sound subsoil, and thus form a complete barrier for the mud. The embankment was carried up to Elev. — 13 feet, and was made 15 to 20 feet wide on top, with natural side slopes. It was deep enough below the water surface not to interfere with the floating equipment used in the construction.

The under-water excavation, which was begun as soon as the dam was completed, proceeded in three successive stages, to 17 feet, 33 feet and 60 feet depth, respectively. The latter depth was required only over small areas, near the outer end of the dock, the general elevation of the foundation being — 54 feet. For excavating the third stage it was necessary to reconstruct one of the dredges by lengthening the ladder. This was done by fixing an extension boom in guides attached to the ladder; the main winch was replaced by one of greater power and an auxiliary winch installed to handle the extension arm. The buckets in this dredge were considerably wider than the wheels of the lower head, so as to clear the latter even when lateral swaying took place. The dredge thus reconstructed is said to have worked without trouble up to the full 60-foot depth, taking out 700 to 2,000 cubic yards (according to the nature of the material) per day of 20 hours.

While the excavation was in progress, the large floating caisson by which the main part of the construction was to be carried out was built on ways in the ship yard, launched and equipped for work. This caisson will be described farther on in this article; in order to describe its manner of use we may mention here that it was simply a rectangular steel box, closed on top and open at the bottom, 138 feet long by 46 feet wide, and 16½ feet high. The lower half of the caisson formed a working chamber, while the upper half constituted a closed tank for water ballast. The caisson was hung by steel rods from a framework erected between two large pontoons, one on each longitudinal side of the caisson, and was raised or lowered by means of the rods. The supporting frame between the pontoons was covered by a working platform from where air-locked wells composed of riveted steel pipes led down to the working chamber. Fig. 3 gives a view of the structure.

In operation, the caisson was placed with its axis transverse to the axis of the dock, extending entirely across one dock chamber, and covering a space of about 46 feet lengthwise of the dock. The caisson was lowered to the bottom (its unbalanced weight being still carried by the rods), and the bottom as left by the dredge was cleaned of the remaining mud. When solid ground was reached, the concreting was begun, and carried up to a height of about 3 feet. The caisson was then raised sufficiently to clear the concrete, shifted lengthwise of the dock to a new position directly adjoining, and lowered again to the desired depth; the process of cleaning the bottom and placing a layer of concrete was repeated exactly as in the first posi-

tion. By continuing this process, the whole area of the first dock chamber was covered with a layer of concrete, crossed, however, by a series of depressions where the cutting edges of the caisson had been. In placing a second layer of concrete in an exactly similar manner, the caisson was shifted so that the cutting edges did not come over the depressions left the first time, but these latter came in the space covered by the layers thus formed. It will be noted that in addition to the depressions left by the cutting edges in each position of the caisson, extending through an entire layer of concrete, a series of shallow grooves is shown in the top layer. These grooves were formed 6 inches deep in the top of each layer, to receive the cutting edges of the caisson when placing the next layer; this ensured that the level of the previously-finished concrete was

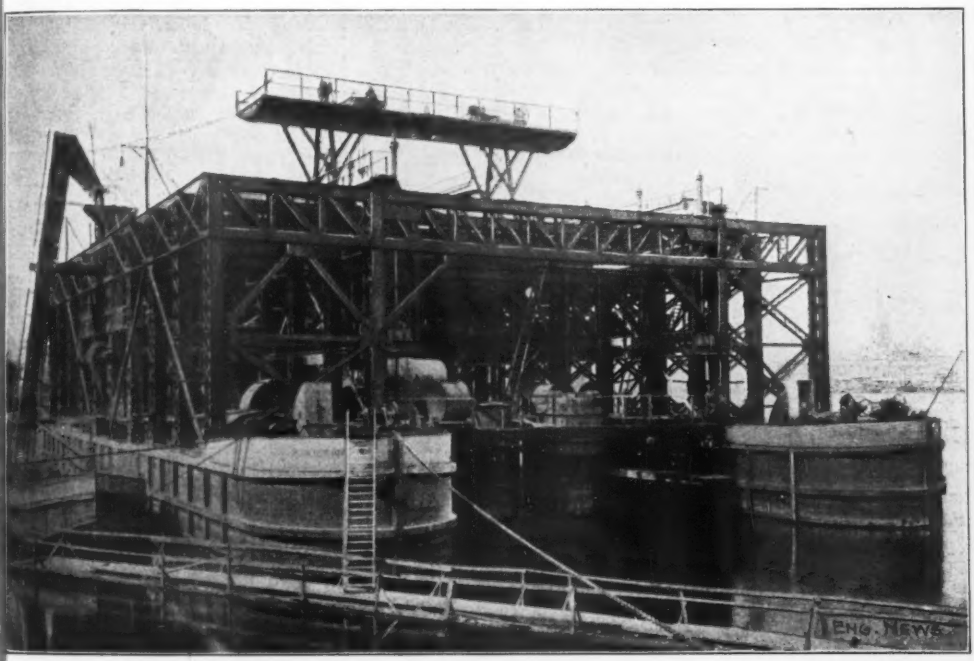


FIG. 3—VIEW OF MAIN CAISSON IN OPERATION.

working chamber, and could thus be filled with concrete, forming part of the second layer. In order to do this without concreting under water (since these depressions were below the new level of the cutting edges), the ends of each depression were first closed off by a dam of concrete, and the water was then pumped out of the trough so formed, leaving it dry and ready for the fresh concrete.

Fig. 4 represents the succession of always above the level of the cutting edges, and hence above the level of the water, except in the deep grooves, which were concreted as described above.

A cross-section through one dock chamber, shaded to show the course of the concreting, is presented in Fig. 5. The dark hatching indicates the layers of concrete placed by the large caisson. Most of this concrete was a trass-lime concrete; Portland cement was added only when low temperature rendered the

trass mixture too slow in setting. The lowest layer, shaded darker than the others in Fig. 5, was made of full cement concrete; this layer rested on a bed of broken stone, by which the clay bottom was leveled up. The trass concrete was made chiefly with gravel, this being considerably cheaper than broken stone. Where special strength was required, however, as in the layers forming the floor of the chamber, and in the middle of the bottom for its full depth, broken

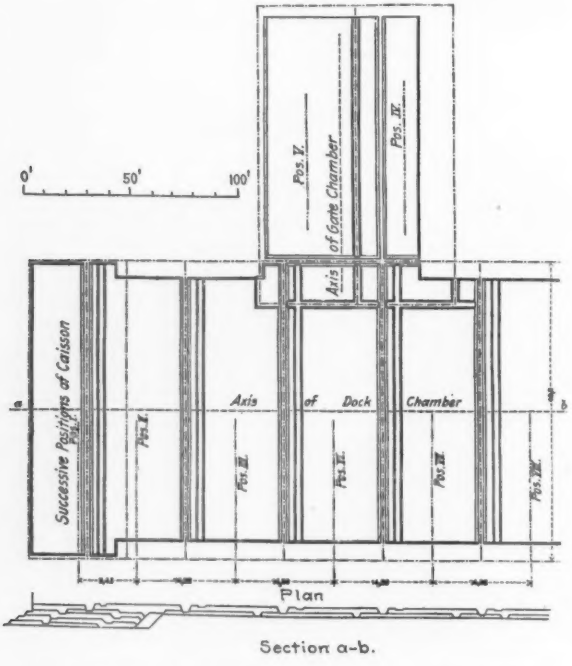


FIG. 4—ARRANGEMENT OF SINGLE SECTIONS OF CONCRETE.

granite was used as the aggregate in place of gravel. The average costs of gravel concrete and stone concrete, ready mixed, but not in place, are stated to have been $2.65 and $3.30 per cubic yard, respectively.

By reference to Fig. 5 it will be seen that the work done by means of the large caisson (as indicated by dark hatching) extends up to Elev. — 10.2 feet only. To use the caisson above this level would have required nearly complete emergence of the caisson, so that its entire weight would have to be carried on the pontoons. Even if the structure were made sufficiently strong for this purpose, the caisson in that position would have been so unwieldy as to very greatly increase the cost of placing the concrete in the upper sections of the walls. A much smaller and simpler caisson was therefore constructed especially for this work, and by its use the walls were carried up to Elev. + 1.6 feet, from where the remainder of the walls, to Elev. + 11.3 feet, could be constructed in the open air.

The small caisson, which is shown in Figs. 10, 11 and 12, and will be described farther on, has a pneumatic chamber wide enough (23 feet) to straddle the dock wall, and 33 feet long, with a height of 6½ feet, which can be increased by lengthening the cutting edges downward by stop-logs (see Fig. 12). The concreting is done in layers of 24 inches, plac-

ing two layers in each single setting of the caisson, from Elev. — 10.2 feet to Elev. + 1.6 feet. In order to get the caisson around the corners of the wall, it was necessary to leave an open space at one side of each corner, as indicated in Fig. 7. These spaces being made long enough to accommodate the caisson lengthways, they could be concreted in a subsequent setting of the caisson, leaving only a narrow vertical slot through the wall at each end of the open space, under the cutting edges. These slots were molded in dove-tail, and were filled with concrete after the caisson work was completed.

The stone and brick interior lining of the dock was placed after the walls were finished; for this purpose the gate was placed against the outer gate notch (formed by the end wall itself, as already mentioned) and the dock pumped out. The pump house, or rather a portion of it, was built simultaneously with the first dock chamber, and was temporarily walled off at the end facing the second dock, so that pumps could be installed and the first dock made ready for use while the second was being built.

The method and course of construction of the second dock was precisely similar to that followed in building the first dock, outlined above. We may note here that the first dock was finally completed and put into service at the end of 1902; at that period the under-water construction of the second dock was completed and only the lining and equipping remained to be done.

MAIN CAISSON.—The size of the structure was limited by the requirement that it should be able to pass through the Kiel ship canal, so that it might be available for work in the Baltic Sea. The caisson proper is, as already noted, 46 feet wide and 138 long (14 x 42 m.) and 16.4 feet deep from roof to cutting edges. Structurally it is composed of a number of transverse girder frames, 8.2 feet deep, braced together by longitudinal frames, and sheeted with a tight steel-plate skin, forming a closed box 8.2 feet deep. The sides of this box are extended downward, braced by triangular brackets on the main frames, to form an air chamber open on the bottom and 8.2 feet high. The box-shaped upper half of the caisson is subdivided by two transverse bulkheads, and the three chambers thus formed are adapted to receive water as ballast. For more accurate adjustment of the buoyancy of the caisson, a closed cylinder of about 125 cubic yards capacity is provided, running longitudinally through the ballast chambers. This cylinder may receive or discharge ballast independent of the main chambers. Compressed air is used to force the water out of chambers and cylinder when the buoyancy of the caisson is to be increased. When the caisson is wholly submerged, and the working chamber is full of air, the caisson has a remaining positive buoyancy even when the ballast chambers are completely filled with water. Fixed ballast sufficient to just neutralize this remaining buoyancy is placed in the pockets of the cutting edges and on the roof of the working chamber in the shape of concrete, pig-iron and old rails.

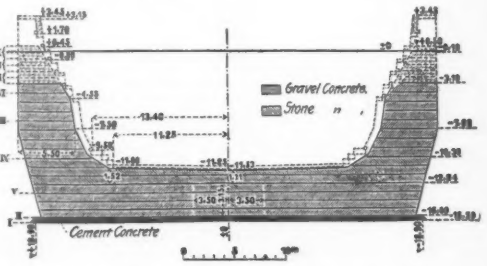


FIG. 5—COURSING OF CONCRETE IN ONE DOCK-CHAMBER.

The two pontoons which carry the supporting structure are simply flat-bottomed steel scows, about 150 feet long by 20 feet wide, which are placed parallel to each other a sufficient distance apart to admit the width of the caisson between them. They carry an overhead steel supporting framework which spans the space between them and firmly ties the two pontoons together. The top of this framework carries a traveling gantry crane fitted with two 10-ton trolleys, which controls the entire area of the working platforms below, and serves to handle all heavy material and parts. Two working platforms are suspended from the framework; the lower one, extending over the full area of the caisson, serves for communicating with the working chamber through the several air-

locked wells, and in general for all the open-air work except handling the materials for concrete, which latter work is done on the upper and smaller platform.

The framework connecting the pontoons also serves as attachment for the suspender rods, by which the unbalanced weight of the caisson is carried and by which the caisson is raised or lowered to any desired position. There are twenty of these rods, one at each side of the caisson at each of the main girders of the overhead framework. They are composed of short lengths connected together by link and pin coupments are reported to have worked perfectly; it wholly eliminates the objectionable feature of nuts rotating under load, and secures a uniform distribution of load between the various suspenders.

The nut and valve mechanism, to which a great part of the success of the caisson is attributed, are shown in some detail in Fig. 6, which is somewhat diagrammatic, however. The main nut has a vertical play of about 1¼ inches in its pedestal. Its outer circumference forms a spur gear, which meshes with a pinion (not shown in Fig. 6) driven from the shaft of a constant-speed motor. A

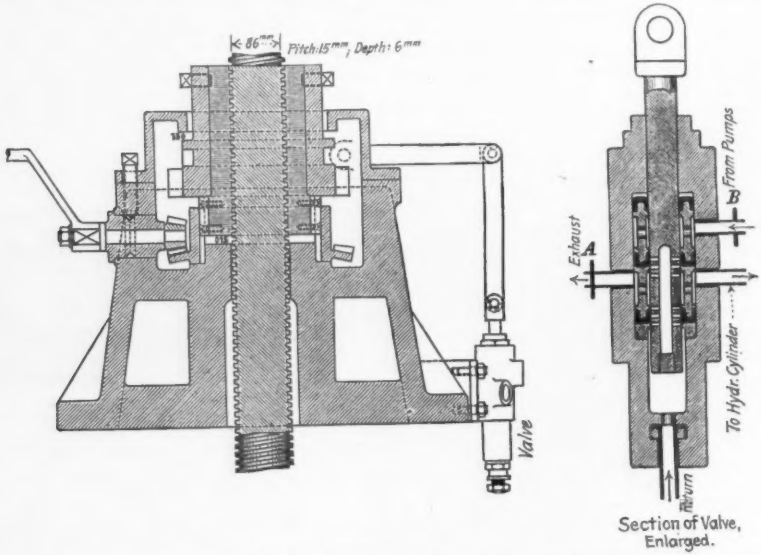


FIG. 6—VALVE MECHANISM FOR HYDRAULIC JACK.

lings. The upper length of each rod is threaded and works in a nut supported in a heavy chair. The upper end of the screw is hung to the plunger rod of a vertical hydraulic jack. The twenty jacks are the means by which the caisson is moved vertically, and the nuts on the threaded sections of the suspender rods serve only as a governing mechanism for the jacks. When the desired position of the caisson has been reached, however, the jacks are placed out of service by shutting off the pressure water, and the load of the suspender rods then rests entirely on the nuts. The arrangetransverse groove in the nut engages the forked end of a lever which is linked to the valve that controls the admission of water to the jack cylinder. This valve and its casing are shown in section to the right. Splined to the nut is also a bevel gear which meshes with a pinion on a hand-crank. By this the nut may be rotated manually when the motor drive is out of order. When the hydraulic jack is not in service the nut rests directly on the pedestal. This brings the stem of the valve into its highest position, and as may be seen from the section of the valve, this po-

sition admits water below the plunger of the hydraulic jack as soon as the cock *B* in the supply pipe is opened. The suspender rod then begins to rise and carries the nut upward with it. When the mean position is reached, water is shut off from the cylinder; this position is represented in the section of the valve, in Fig. 6. If, however, the nut is rotated, and thereby screwed downward on the rod as the lifting proceeds, it will hold the valve open. By rotating the nut in the opposite direction, screwing it upward on the rod, water is exhausted from the cylinder through the pipe in the bottom of the valve, and the suspender rod is lowered. When the desired motion, either raising or lowering, is completed, the pumps are stopped, and the jacks then gradually settle down until the nut of each suspender rests on its pedestal and thus takes the load of the rod. In this position the valve is open to admit pressure water as soon as the pumps are started.

The jacks have a range of motion of about 8 feet. In normal operation they raise or lower at a rate of 1½ inches per minute. Four 5 horse-power reversible induction motors are provided for rotating the nuts, one motor for five suspenders. For raising or lowering a longer distance than the stroke of the jack, the suspenders must be lengthened by inserting an additional section. This may be done even when raising or lowering the caisson, and the lengthening may be in progress on four suspenders simultaneously, the remaining sixteen being ample to carry the load. For this purpose the nut on each suspender is made in two concentric halves, the inner being the nut proper, while the outer one carries the operating gear; the two sections may be disconnected by loosening the set screws that connect them. When any nut is thus disconnected, its outer shell may be rotated by the motor without moving the nut, and the corresponding jack will then remain out of action while the remaining jacks lift the caisson and take the load off the suspender in question. It is then a simple matter to disconnect the screw portion from the suspender proper, actuate the nut by the hand gearing, so as to set the jack in action and raise the screw, and finally when the screw is in its topmost position insert a new length of suspender.

It remains to mention that each jack cylinder has a safety valve set at 100 atmospheres, corresponding to a load of about 19 tons per jack. If this load is exceeded, the safety valve allows the water to escape and the suspender settles to bearing on its nut. The latter is then held by its friction so that it cannot be rotated until the load is reduced to the capacity limit of the jack.

The pressure water is supplied by a triplex pump driven by an induction motor of 15 horse-power. A 4-gallon accumulator serves as storage reservoir, and by its position automatically starts or stops the pump. The liquid used is water mixed with about 30 per cent. of glycerine.

There are seven vertical shafts or wells connecting the working platform with the chamber of the caisson; the shafts are composed of riveted steel pipe and are made in sections so that lengths may be added or removed as the caisson is raised or lowered. The weight added or removed in this way is balanced by pumping water into or out of the cylindrical ballast tank in the upper half of the caisson. Of the seven wells, four are utilized for materials, two are for persons, and one for concrete. All the shafts have air locks at the upper end, and air-tight doors at the lower end for closing the working chamber when the shafts are being shortened or lengthened. Of the four material shafts two are fitted with motor-driven elevators, while the other two merely have covers at top and bottom, constituting a full length air-lock for handling long timbers, etc., into the working chamber.

The concrete shaft forms a simple chute with lining tube, down which the concrete falls. The chute is kept full of concrete, and two laterally-extending hoppers at the lower end permit its contents to be tapped off as needed into buckets running on overhead trolleys in the working chamber of the caisson. The upper end of the chute is fitted with a double hopper, both compartments of which discharge into the inner tube of the shaft. The two compartments are filled alternately, and each has an air-tight trap door at top and bottom, so that one compartment may be filled while the other discharges into the

chute. The upper and lower door of each compartment are interlocked, so that only one can be open at any one time. The small air lock at the side of the top end of the chute serves to admit two laborers into the space just beside the hopper, for operating the bottom trap doors of the hopper compartments.

The two shafts for workmen are each fitted with a head, constituting a double air lock. The smaller chamber will contain four persons, while both chambers can accommodate up to twelve at one time. The valves for admitting air are specially designed needle-valves, in which the amount of port opening depends on the difference in pressure across the valve, so that at the beginning of equalization a much smaller opening is presented than toward the end of the operation. They are proportioned to give a pressure increase or decrease at the rate of 0.1 atmosphere per minute. This full rate is employed in the operation of locking in, while when locking out a second valve admits fresh compressed air at half this rate, so that the effective rate of locking out is only 0.05 atmospheres per minute. The use of these automatic valves makes it impossible for workmen to lock in or out at a dangerously rapid rate. Special cocks of ordinary construction are provided for special purposes, but these are arranged to be operated only by foremen or inspectors.

The two shafts containing the two material elevators are located side by side, so that the two hoisting skips could be counterbalanced through their connection to the same hoisting-motor shaft. This shaft drives by worm-gearing a lifting sheave over the centre of each well, and a sprocket chain attached to the skip passes over this sheave. The slack in the chain is taken up in a three-part rigging held taut by a weight, this rigging and weight being contained in a small air-tight auxiliary well at the side of the main well. The hoisting motor is automatically shut off, and a magnetic brake applied, when either skip nears its highest position. To draw it up so that its bottom plate forms an air-tight seal against the bottom ring of the air lock, a hand hoist is thrown into gear by a foot lever, which latter also releases the magnetic brake. The hoisting motor is a 20 horse-power induction motor, but direct current is required for the magnetic brake.

The skip is a simple skeleton frame carrying a horizontal track rail, on which runs a trolley carrying the bucket. When the skip is in its upper or lower position, the trolley track registers with a similar overhead track respectively on the working platform and in the caisson chamber. The bucket is thus quickly run out and a new one run into the elevator. The bottom of the skip bears a horizontal plate, slightly smaller than the well, whose upturned edges in the upper position of the skip make a tight seal against an angle-iron ring riveted to the skin of the well.

For handling buckets of earth, concrete and other material in the caisson, a series of trolley tracks, communicating by turntables, is hung to the roof of the working chamber, on which buckets may be run to or from any part of the working chamber and any of the wells. Similar overhead tracks are provided on the lower working platform for handling the buckets of the material elevators. On this platform are also installed three batch concrete mixers, each holding about 1.6 cubic yards, which discharge into small dump cars running to the concrete chute.

The remaining mechanical equipment of the caisson structure comprises a chain-and-bucket elevator on one side of the structure for raising mortar from lighters alongside to the upper platform; three 1-ton electric jib-cranes on the other side for hoisting gravel, broken stone, etc., to the concrete platform; four air pumps, each driven by a 30 horse-power induction motor, installed in the hold of one of the two pontoons; the 10-ton electric gantry (already mentioned) on the top of the supporting framework; and the necessary air piping, etc., for supplying the working chamber and ballast chambers and for blowing out water, mud, etc., from the working chamber. It is interesting to note that the chain-and-bucket elevator for mortar showed such rapid wear that it was soon replaced by a simple hoist.

Power was supplied to the structure by three electric cables leading from a temporary power station on shore. Two of these are duplicate three-phase cables supplying current at 330 volts to the various motors on board, while the third

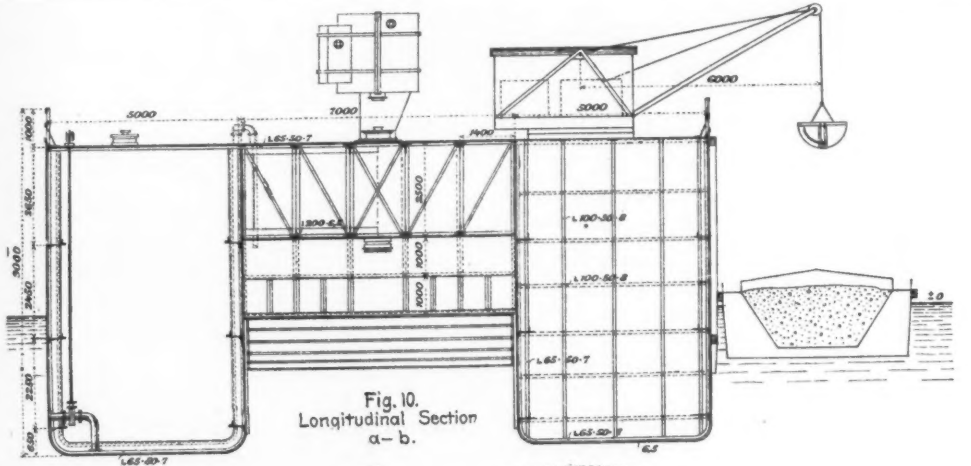


Fig. 10.
Longitudinal Section
a–b.

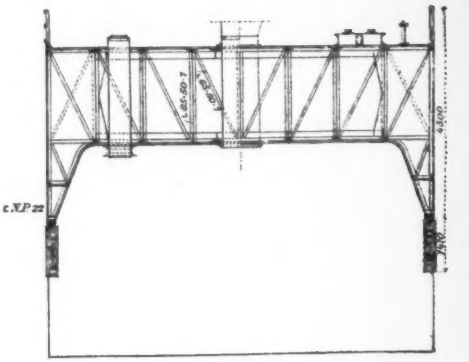


Fig.12.
Cross Section.

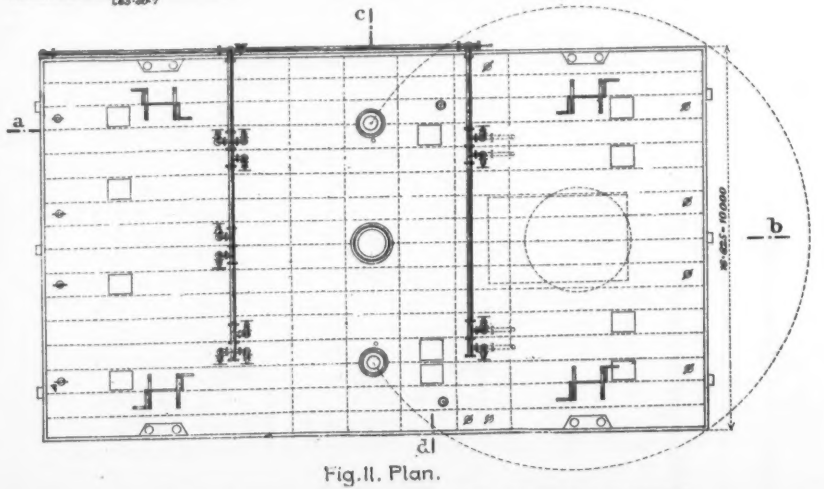


Fig.11. Plan.

FIGS. 10, 11 AND 12—PLAN AND SECTIONS OF SMALL CAISSON.

supplied direct-current at 110 volts for lighting and for the magnetic brake of the material elevators. The cables were hung to buoys about 100 feet apart in such a manner as to swing clear of the bottom. About 250 horse-power were required for power and 10 to 15 horse-power for lighting. Incandescent lamps (16 candle-power) were used in the working chamber and air locks, while both arcs and incandescents were used on the platforms.

SECONDARY CAISSON.—This is sufficiently shown by the drawings, Figs. 10, 11 and 12, and need not be described at length. It differs in general principle from the main caisson in having the pontoon portion and the caisson portion rigidly combined in a single structure. The pontoons and the upper half of the caisson constitute ballast chambers. The

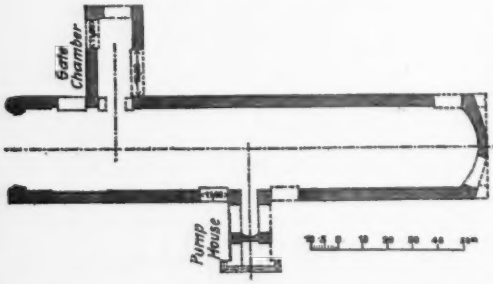


FIG. 7—PLAN OF ONE DOCK-CHAMBER, SHOWING METHOD OF CONCRETING WITH SMALL CAISSON.

horizontal dimensions of the working chamber are 33 feet by 23 feet, and its normal height is 6½ feet. This may be increased, however, by inserting stop-logs in channel frames at each end of the caisson, as shown in the drawings. Three air-locked wells lead from the deck of the structure to the working chamber, two for concrete and one for workmen. The concrete chute was, of course, much simpler than that of the main caisson; the well was simply fitted with interlocked trap doors at top and bottom, and thus formed a full length air lock, into which the concrete was dumped from the deck, and from which it dropped into the working chamber.

This smaller structure did not carry a concrete-mixing plant, but was supplied with concrete already prepared elsewhere, by lighters. An electric jib-crane of 2 tons capacity, on the deck of the structure, served to handle the concrete and other materials.

CONCRETE.—As the amount of concrete in this double dock reached the figure of 200,000 cubic yards, all but 15,000 cubic yards of which was placed under air pressure, it may be recognized that the arrangements for preparing the concrete with a minimum of handling at the caisson demanded careful attention. The fact that but little Portland cement was used, practically all the concrete being made with trass, makes the plant radically different from those that are used in American practice.

The plant was established at a point along the harbor shore about a mile distant from the building site. The trass rock was brought to this place in vessels, and after unloading went through crushers, which broke it to a 2-inch size. The quicklime, also received by vessel, was slaked in a series of pits. Sand, obtained from the bank directly at the mixing plant, went through two rotating screens, which separated it into sand, gravel and stones. The stones were broken for use in mixing the concrete, and both gravel and broken stone were shipped to the caisson in scows. The mortar was prepared at the mixing plant in a set of eight rotating-pan edge-runner mills, in the following manner: The broken stone trass was first charged into the mills and ground for a few minutes; then the slaked lime was added and ground well into the trass; finally the proper amount of sand was added and the whole mass ground up together, water being added when required. The finished mortar was shoveled into dump cars running out on a pier, where they discharged into scows. At the caisson the scows were run directly alongside and the mortar unloaded by the hoist already described.

The edge-runner mills required about ten minutes running per batch. The maximum daily demand occurred when both the main and the auxiliary caisson were at work, and amounted to 300 cubic yards of mortar, corresponding to about 600 cubic yards of concrete; this amount could be turned out by the plant in about 17 hours of work. The proportions used in making up this mortar were determined from a series of tests

of various mixtures, resulting in the selection of a mixture of 5 parts lime, 6 parts ground trass rock, and 8 parts sand, by volume. This mortar, tested after 16 days (48 hours in air and 14 days in water), gave a tensile strength of 175 to 225 pounds per square inch, and after 28 days 285 to 315 pounds per square inch. At temperatures near freezing, such trass mortar or concrete made from it sets too slowly, and under those conditions about 10 per cent. of Portland cement was added to the mortar to make it quicker in setting.

The concrete was mixed in the proportion of 1 part of mortar, by volume, to 2 parts of gravel or stone, making about 2.2 parts of concrete. The broken stone was obtained in part by crushing the large stones screened out of the bank sand, and in part directly from granite quarries in the neighborhood. The gravel, which was obtained from the bank sand by screening varied in size from ⅛-inch to 2 inches diameter.

Costs.—The cost of the two caissons, including all equipment and accessories and the mortar-making plant, amounted to 850,000 marks, or about $200,000. The operating cost, including interest and depreciation on the plant, wages and repairs, was about $30 per working hour, or something less than $720 per day. The cost of the concrete, which was the principal material used in the work, amounted to about $2.65 per cubic yard for gravel concrete and $3.30 per cubic yard for stone concrete. It is calculated that the cost of putting the concrete in place amounted to about $3.25 for concreting in the caisson, against about $1 for concreting in the open air. The price paid for the dredging, in depths up to a maximum of 68 feet, varied from 11 cents to 36 cents per cubic yard, depending upon depth and nature of material.

The preceding article has been prepared from a full description of the work given by Messrs. Franzius and Mönch, the engineers in charge for the government, in the official journal of the German Ministry of Public Works, the *Zeitschrift fur Bauwesen.*

The contractors for the entire construction were Ph. Holzmann & Co., of Frankfort a. M. To this firm is due the credit of suggesting the use of the floating caisson and working out the whole scheme of attack.—*Engineering News.*

Power Signaling on English Railways.

The *Illustrated Scientific News,* an English publication, contained in its January issue an article on "Power-Signaling on English Railways" by Cyril Hall. In the course of the article Mr. Hall says:

"It is the electro-pneumatic signal which has the greatest vogue in this country. Of the several schemes which we shall endeavor to describe—all of which have points in their favor—the Westinghouse is the best known and longest tried. The Westinghouse electro-pneumatic system has passed the experimental stage, and though, of course, it is being improved year by year, and is being continually adapted to different modes of working on various railway systems, it may justly claim to be responsible for the introduction of practical power-signaling into England. From motives of space we shall be obliged to deal with the Westinghouse system in a separate article.

"In 1901, Mr. Sam Fay, who was then superintendent of the line of the London and South-Western Railway, recommended to his Directors, as the outcome of an American tour, that the British Pneumatic Railway Signal Company's apparatus should be installed on the South-Western line at Grateley, an important junction on the Exeter main line. This is a system of inter-locked signals and points operated by low-pressure air. Some of the main characteristics of this system are that it requires a low air-pressure—about 15 pounds to the square inch; that except when a lever is being actually used to operate points or signals this pressure is withdrawn, and the apparatus and conduit pipes are subject only to atmospheric pressure; that, since the final stroke of the lever in the frame is automatic, it is only the admission of air that requires the attention of the operator, and much heavy manual labor is thus abolished. Moreover, since an indication or "return" is always given, it follows that in this system, as in others, the signalman can devote more attention to the opening and closing of his sections, and need not be anxious concerning the failure of a certain signal to work. The cardinal provision is made that in case of absence or failure of the power—which seems remote—an affected semaphore will return to the "danger" position. Positive application of power is in every case necessary to move a signal or switch.

"The increased safety and quick action of the pneumatic movement has induced the Board of Trade to sanction a valuable increase in the distance over which signals and facing points may be worked. The L. and S. W. Ry. have, in addition to the Grateley installation, pneumatically worked signals at several other places on their line, including busy sections at East and West Staines. One great advantage arising out of the saving of labor is the more thorough concentration of lever frames, in many cases one cabin taking the place of two or more necessary for the old mechanical system. The essentials of the British Pneumatic Signal Company's apparatus may be said to consist of a diaphragm valve, main valve, and indicating valve attached to the operating bar or lever, air compressors and reservoirs, and the switch and signal movements. The necessary power can be supplied by a small gas or oil engine.

"As already mentioned, when 'track circuit' is employed, the safety and efficiency of the pneumatic system is considerably increased. Since the maintenance costs no more than that required for the electric treadle, and the effect of replacing a lever and holding it in the normal or 'back' position by the passing train renders the train to a certain extent independent of the signalman, or, in other words, protects itself, this will be readily understood.

"Owing to the small insulating resistance of the track itself, the electro-motive force has to be very low, and is never greater than 1.5 volts. Thus there is little leakage. The current on the track, unlike the air, is always operating. In the British Pneumatic Company's system all the circuits are kept separate, so the failure of one circuit will not interrupt the others. This is a point which, in some all-electric systems, has not received much attention, as cases have been known of a single leakage locking up a whole machine. The electrical relay, the electro-pneumatic valve, and the electro-pneumatic cut-off valve are the vitals of the track circuit when used with the low pressure pneumatic. The relay consists of an electro-magnet, which, when energized, attracts an armature. To this armature is attached a circuit closer spring, and whether this is open or closed, thus making or breaking the circuit, depends on whether the magnet is energized or not. The electro-pneumatic valve consists of a simple electro-magnet, on the top of which is fastened a valve. This and the electro-pneumatic cut-off valve are very similar in construction, but their functions are totally opposite. The electro-pneumatic valve is so designed that when the magnet is energized and the armature lifted, the ports in the cylinder are open to admit air through the valve, and when the magnet is de-energized these ports are closed.

"The action of the electro-pneumatic cut-off valve is, as has been mentioned, exactly opposite to this, and in the first-named condition the ports are closed, and when the magnet is de-energized, the ports are open for the passage of air."

Caisson Disease.

The sudden death of an inspector upon emerging from a caisson of the Manhattan Bridge has called public attention in New York City to the danger attending such work as now conducted. This death has been preceded by the deaths of four laborers upon the same work; and, now that the work is nearly completed, the Board of Health has been roused to investigate the cause and the possible remedy.

In our issue of September 5, 1901, the occurrence and treatment of caisson disease were discussed at length, and we do not purpose repeating what was then said further than to call attention to the fact that caisson work in this country has been done at the expense of far too many lives. A brief summary of the loss of life on some of the important works where compressed air has been used may serve to emphasize the danger.

In the East River Gas Tunnel, where the greatest depth below water was 120 feet, there were four deaths among the 15 men who suffered from the "bends," and this in spite of the fact that all workmen underwent a careful physical examination before admission to the air lock.

On the Eads Bridge, at St. Louis, Mo., a depth of 110 feet was reached at the cost of eight lives. There were 77 cases of caisson disease on this work, in spite of physical examinations and the use of stimulants.

On the Brooklyn Bridge work, where the maximum air pressure was 36 pounds, there were three deaths out of 110 cases of the "bends," of which 13 were so serious as to be accompanied by paralysis.

On the Williamsburg Bridge, just com-

pleted over the East river, New York, although a depth of 100 feet was reached, only a few mild cases of caisson disease were developed. The only precautionary measures used were to provide a warm room, baths for the men upon leaving the caisson, and to supply them with plenty of strong coffee.

Including the Manhattan Bridge, now under way, we have a record of 20 deaths on five large contracts involving the use of compressed air at great depths. Taking no account of the suffering and physical injury to some hundreds of workers, this is a record that deserves the serious consideration of engineers and contractors. Cannot the number of deaths and the suffering on future work of this character be lessened? and if so, how?

In this issue we publish an illustrated article descriptive of the automatic air valves used in caisson work on the dry-docks at Kiel, Germany. The object of such a valve is to make it impossible for workmen to pass through the air lock in so short a time as to cause serious risk of injury as is now the common practice in this country. The automatic valve is so constructed that after entering the lock from above the men cannot leave it for a period of 20 minutes, during which time the air pressure is gradually increasing until it equals the pressure in the working chamber below. In coming out of the working chamber the men remain in the air lock for 40 minutes, during which time the pressure is gradually reduced until it equals that of the atmosphere. It is a well-known fact that rapid locking out is far more injurious to the men that locking in, hence the difference in time at which the automatic valves are set to work.

If each man works two shifts a day it is obvious that two hours are daily lost in locking in and out; but is not the purchase of good health and safety worth the price? The men, it is true, will not voluntarily submit to so much "lost" time, hence the necessity of some such automatic device that is beyond the control of those in the lock. The contractor will not voluntarily use a safety device that the men themselves would object to, hence the necessity of prescribing the device in specifications if it is to be used at all. This is in fact the nib of our argument. Engineers who have the drawing of specifications for deep compressed air work should specify, for one thing, a minimum time to be consumed in locking in and out. If the engineer has neglected to do so, looking upon the handling of the men as beyond his province, then the Board of Health appears to be the only authority that can compel action to insure the safety and well-being of the men.

We have not spoken of the treatment that men should receive once they show symptoms of caisson disease, but among the most rational and thus far the most effective, is a compressed air hospital, which is in fact a small air lock into which the patient is placed, and left under air pressure until the pains subside. This "hospital" might well be required in the specifications for caisson work where high pressures are to be used, in view of the practical certainty that there will be a number of sufferers from the "bends," regardless of every precaution.

In closing this brief summary, we may add that were such precautions taken as have been suggested, they would in all probability so reduce the suffering and the mortality as to reduce the rates of wages now demanded by workers in compressed air, and thus eventually reduce the cost of engineering structures involving caisson work.—*Engineering News.*

[The article referred to, on the caisson work at the Kiel Dry Dock, Germany, will be published in a coming issue of COMPRESSED AIR.—ED.]

Compressed Air in Glass Blowing.

Mention has already been made in COMPRESSED AIR of the introduction of compressed air in the bottle-making industry. After following for centuries the old method of blowing bottles "by hand," the trade expression for using men's lung power for that purpose, it has been discovered that far better results and greater economies may be obtained by using air mechanically compressed for making the cheap and middle grades of bottles. Experiments along this line have been conducted for some time and have been uniformly successful. This method is now in satisfactory operation at the Alton, Ill., plant of the Illinois Glass Co., which is considered one of the largest and most progressive shops of its kind.

By the old method the requisite amount of molten glass was drawn on the end of the blow pipe through a small opening in the furnace. After it was worked to the proper shape and cooled to the required temperature it was placed in the mould

and blown into the desired form by lung power.

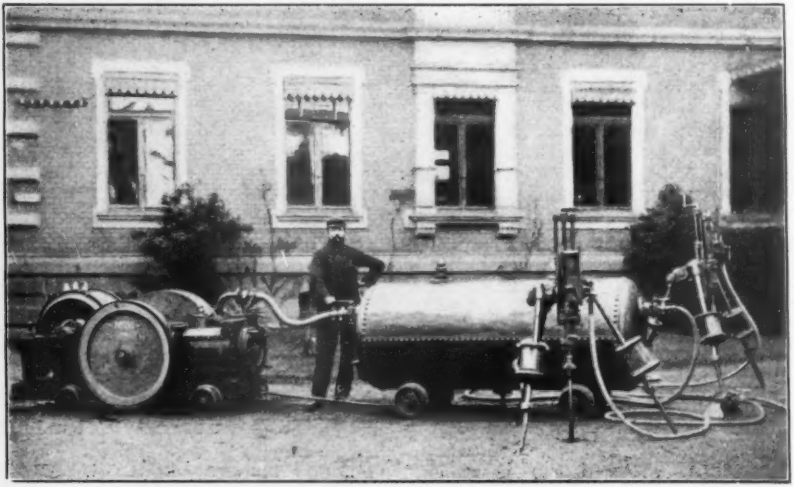
The machine, which has been designed to take the place of the man, will blow wide-mouthed bottles of all sizes with the aid of compressed air. The moulds are of cast iron divided longitudinally and hinged on one side so they may be opened and the bottle removed.

One of the chief difficulties was to secure perfect shapes of uniform thickness. To overcome this it was found necessary to keep the moulds at a uniform temperature, which was discovered only after careful experimenting. An ingenious method of retaining the desired temperature of the mould has been devised, currents of air being circulated through it to carry off the surplus heat as necessity requires. It was found that should the mould be a little too cold the glass was chilled and failed to flow freely or fill the form completely. When the mould was too warm the result was that the glass adhered to it, resulting in defective spots.

The supply of compressed air for blowing the machine-made bottles is secured from an electric-driven Ingersoll-Sergeant air compressor, having a capacity of nearly 1,000 cubic feet of free air per minute. This machine compresses to a pressure of 85 pounds to the square inch. This plant is fully equipped with an electric power transmission system, so that the electric-driven air compressor can be operated without difficulty and at little additional cost.

A Portable Electric Driven Air Compressor.

In a recent article in the *Engineering Magazine* on the subject, "Electric Power in the Mines of Europe," there is a description of an unusual type of an electric driven air compressor. This is in use by the Schückert Company, a German concern. As the illustration shows, it consists of an air compressor, driven by an electric motor, and a compressed air reservoir arranged to run on rails and to be thus moved to the scene of action. Short lengths of hose carry the air from the reservoir to the drills. In a mine equipped with the electric current this means is used to utilize the electricity and still secure the advantages which can be gained through the use of compressed air.



Frost Trouble with Compressed Air Apparatus.*

Every one who has had to do with compressed air machinery knows that when the temperature descends to the neighborhood of 35 or 40 degrees F., he will begin to have trouble. This trouble generally takes the form of a closing of the exhaust ports with a mass

*By Forrest E. Cardullo, in *The Engineer*; reprinted with illustration through the courtesy of *The Canadian Engineer*.

of snow and ice; but it will often be found that valves stick from frost gathering on their rubbing surfaces, and pistons and stuffing boxes bind from the formation of ice.

One cubic foot of air at a temperature of 40 degrees F. will contain just 3 grains of moisture as vapor, and no more. It matters not whether the air pressure be 1 pound or 100 pounds, if there be any more moisture than 3 grains per cubic foot it will condense as water and not remain as vapor unless the temperature be raised above 40 degrees F. Suppose now that we have an air compressor delivering air at 30 pounds gauge. It must compress three cubic feet of free air into one of compressed air, and if each of these three held 3 grains of moisture a small quantity, but with even the smallest size compressors it amounts to 4 or 5 gallons a day. If the temperature falls to 32 degrees or below, the water in the lines quickly freezes, stopping the air supply, if it does nothing more serious. Care must be taken while erecting the lines to have the drip-cocks at all the low points, through which every day or two the accumulation of water may be blown out. This simple and inexpensive expedient will save much trouble from broken and leaking lines, due to freezing and water hammer, and will increase the capacity of the line by allowing the air the full area of the pipe, where it would otherwise have only a half or a quarter of the area, the remainder being full of water.

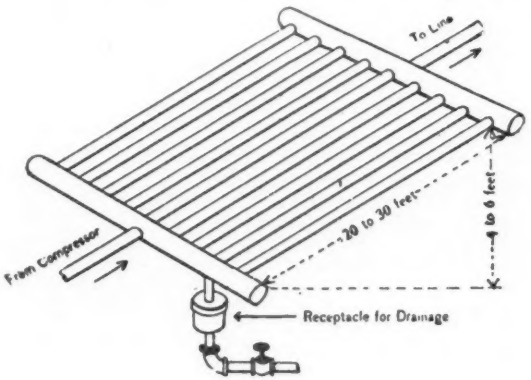


FIGURE NO. 1.

at a temperature of 40 degrees F., after compression, one cubic foot will contain 9 grains of moisture.

Air heats on compression, so that this moisture will leave the compressor in the form of vapor, the air being able to hold it in that state on account of the higher temperature. This heated and moisture-laden air leaves the compressor and enters a long line of cold pipes, where it is quickly cooled to its original 40 degrees temperature, and every cubic foot of it has 6 grains of moisture to deposit. The larger part of this water remains in the pipes, but some of it is borne along with the air current in the form of tiny globules, enters the drill or motor, and passes out with the exhaust.

Five or six grains per cubic foot seems

Air cools so fast on expansion that it precipitates moisture, which, however, gives very little trouble, for it is frozen almost the instant it forms. So instead of forming chunks of ice in the exhaust it is blown out in the form of extremely minute ice crystals. On the other hand, when the air carries moisture in the form of mist or spray it is deposited as water, and then frozen where it is deposited. The moisture that gives the trouble, then, is the moisture that may be removed by cooling the air back to the temperature of the atmosphere before it is sent to the motors.

Many compressors are equipped with water after-coolers for this purpose, but when the temperature of the cooling water is higher than that of the atmos-

phere they are more or less inefficient. For some classes of work they are also too cumbersome, expensive, and liable to freeze or get out of order. An after-cooler, which meets the requirements of out-door winter work, and is much more efficient in all temperatures below 38 or 40 degrees than any water cooler can possibly be, is illustrated in Fig. 1. It consists of two manifolds connected by lengths of 1½ or 2-inch pipe. The air enters at the lower manifold and passes up the incline, depositing its moisture, which runs back and settles in the spill pot A, attached to the lower manifold. It will not readily freeze up, because the air parts with most of its moisture before being cooled to the freezing point, and what little is deposited after that is accommodated by the ample pipe section. A number of pipes are necessary in order that the air may have ample time to cool, and may not have to pass through them with such velocity as to carry some of the water with it.

A cooler of this type can be "built with a monkey wrench" from second-hand pipe and fittings. The threads should be liberally smeared with asphaltum varnish before making up the joints, and leaks will be unknown. For air work, asphaltum varnish is infinitely superior to red or white lead, graphite, or any other joint cement in ordinary use. In case a receiver or storage tank is used it is better to connect the cooler between the compressor and tanks, that the air may have additional time and opportunity to deposit its moisture. In case the cooler does become clogged with ice, as is possible in extreme weather, it being out of doors, a torch or small bonfire may be used with perfect safety. It will, however, take a long period of very cold weather to freeze it enough to make that necessary.

Compressed Air as a Motive Power Underground.*

Compressed air is particularly adapted as a motive power underground. It improves the ventilation of a mine; cools hot places when the machines are working; it can be kept in storage and suffers no loss. There is, however, a great loss shown by numerous experiments between the power required to compress air and the work got out of the rock drill or motor. It is now generally accepted that not more than 30 to 35 per cent. efficiency can be procured; in other words, it takes 3 h.p. at the compressor to develop 1 h.p. at the motor. One of the principal reasons of this loss of efficiency is the generation of heat by compression. This heat is entirely lost, or produces no useful effect, and, as previously stated, represents exactly the same amount of work. The heating of the air during compression causes a serious loss in another way, because by raising the temperature of a gas one degree we increase its bulk one volume in 460, or if we compressed 460 cubic feet of air and raised the temperature from 60 degrees F. to 300 degrees F. (which represents the temperature of air at a pressure of 90 pounds per square inch), we would have done work upon 700 cubic feet of air instead of 460 cubic feet, or nearly one-third more work done than if the temperature remained constant.

When the air leaves the compressor cylinder the radiation of the heat commences, and the air soon cools down to the original temperature, 60 degrees F.; and what was 700 cubic feet again becomes 460 cubic feet. Most of those who have been working with a rock-drill or air-winch, may have noticed how cold the exhaust chambers were when working. This is caused by the sudden expansion of the air. This also represents a loss of work, owing to our inability to get as much expansion out of the cold compressed air as we would have done had it remained at the temperature due to compression. To minimize these losses as far as possible has been the constant endeavor of builders of air compressors.

The principal means adopted to reduce the temperature is the water jacket. By this means it has been estimated that two-fifths of the temperature due to compression is absorbed by the water circulating around the air cylinder. You will now see the necessity of having a rapid circulation of water through the water jacket. The high temperature would also have a most injurious effect

*An abstract, prepared by the *Queensland Government Mining Journal* (Australia), of a paper read before the Monkland Improvement and Debating Society, Gympie, by T. G. Oliver, manager, 2 North Columbia Smithfield, Gympie.

upon the packing of the piston rods, the lubrication of the cylinder, and valves of the air compressor. It would also expand the air entering from the atmosphere to a much greater extent, and thus the air compressed would be less in bulk when it had cooled down in the receiver and pipes leading into the mine. This reduced volume would therefore represent proportionally a smaller amount of work got out for the large amount put in. We know that the efficiency of a machine is reckoned by the difference between the work got out and the work put in. We will take, for instance, a common pressure on Gympie—100 pounds per square inch. It has been proved by experiment that with air compressed adiabetically to 100 pounds pressure, the temperature would be 482 degrees F., but by cooling it with water jacketing, the temperature is reduced to 314 degrees, or by almost a third.

A nice little experiment may be performed by any one which will prove conclusively to them the great heat generated by compressing air. It was used for kindling fires before friction matches came into use. Get an apparatus consisting of an iron barrel with a bore three-eighths inch in diameter and eight or nine inches deep; make a steel piston the required length and accurately fitted and perfectly air tight, but so that it will move easily when lubricated. The end of the plunger has a small cavity and a collar eight inches from the bottom, to prevent it striking the bottom of the bore hole. A piece of tinder is placed in the cavity of the plunger and inserted in the barrel. Then by a sudden movement you push the plunger home, withdraw it quickly, and you will find your punk on fire, by the sudden evolution of the temperature to a red heat, caused by the compression of the air in the cylinder before the insertion of the plunger.

The most approved method of reducing the loss of power caused by the rise in temperature by single stage compression is to compress it into two or three stages, and complete cooling between each stage—that is, in two or three cylinders, with the pressure increasing in each cylinder, with an intercooler between. For pressures approaching or over 100 pounds per square inch, compound compression is being almost universally adopted. Even for pressures of four atmospheres the extra first cost of a stage compressor will pay for itself in a short time, because you have seen that the temperature increases rapidly as the pressure increases. This is obviated by compound pressure, because the diameter of the cylinder is so proportioned as to divide the work of compression equally between the cylinders. The cylinders, like those of single stage compressors, are provided with water jackets, and are connected by an intercooler. Free air is admitted into the low pressure cylinder, then forced into the intercooler; there the heat of compression is removed before it is taken on its journey by the next cylinder.

The advantage of compound over single stage compression lies in the reduction of work due to loss of heat, since the resistance due to compression is directly proportional to changes of temperature. We also have a cooler cylinder which does not expand the air so quickly; hence a larger volume would be compressed by each stroke of the piston. There would also be less chance of the oil carbonizing; therefore we would have better lubrication in the air cylinder.

There are two other fertile causes of loss of efficiency in air compressors. These are losses caused by the friction of the air traveling through pipes of insufficient diameter, and clearance losses. The loss due to friction in pipes of insufficient diameter is very great. In a test which I made a few weeks ago, rather more than 1,800 feet from the receiver on the surface, 1,400 feet of this length being 2-inch pipes, and 400 feet 1-inch, I found a loss of 30 pounds pressure at the drill, with 100 pounds pressure at the surface receiver; with 80 pounds receiver pressure the loss was 25 pounds at the drill. The speed the air would have to travel through a 1-inch pipe to supply a 3½-inch drill would most certainly cause it to be wire drawn. Knowing the great friction caused by this velocity, I considered it advisable to substitute 2-inch pipes right up to the drill. With these pipes I made similar tests under similar conditions to those that were made on the 1-inch pipe, and found that the

loss was, with 105 pounds receiver pressure, 10 pounds at the drill, with 100 pounds, 9 pounds loss, and with 85 pounds, 7 pounds loss at the drill. Our drills are 3½-inch cylinder, and a 6-inch stroke now allows an effective piston area. After deducting the area of the piston rod in one end and the rifle bar in the other, of 7¾ square inches, and a stroke of 6 inches and 300 blows per minute, we see that each blow struck by the drill would use 93 cubic inches of air. That would be the effective piston area multiplied by twice the length of stroke, and this multiplied by the number of blows (300) per minute, would give the number of cubic inches of air required per minute. From this it will be seen that there is 27,900 cubic inches of air used per minute, and as the inch pipes are only .7854 of an inch in area, the air would have to travel at a speed of 35,523 lineal inches per minute, or nearly 50 feet per second. This proves that there must be an enormous loss from pipes of insufficient diameter, as the friction increases not directly as the velocity, but as the square of the velocity.

In addition to the friction, there are losses in bends, elbows, and T pieces. With 2-inch pipes under the same conditions, the air would travel only 12 feet per second. A few weeks ago I saw, in one of the compressed air systems on Gympie, four elbows and a T piece in about a dozen feet of air pipe. According to what has been said, in laying pipes they should be able to deliver a little more than the drills are capable of taking out, and at the same speed. All abrupt turns, such as elbows and T pieces, should be avoided, and wherever possible bends substituted; also all joints should be well made.

Another and very effective way of reducing friction in the pipes would be to have a receiver underground near to the drills or other machine. By putting in a concrete wall in any drained crosscut, level, etc., they could be utilized for this purpose. It would serve to settle all moisture in the air, also maintain a steady pressure on the machines using the air. They can be made more cheaply than an iron receiver, are several times larger, becoming as it were accumulators of power while the machines are stopped, and even if a slight mishap occurred to the compressor on top, the machines could go on working.

The loss from clearance is more a loss of volume than of power. We must first of all understand what clearance loss means. In making a compressor it is undesirable that the piston should strike the cylinder cover every stroke, but unless this were done there would be still air between the piston and cover. This is practically what takes place in most compressors at the present time. There is always a space between the piston and cover which is filled with air at a pressure 2 or 3 pounds in excess of the gauge pressure. When the stroke is reversed, this air expands again to atmospheric pressure before the piston commences to draw in air from the atmosphere; but, as I said before, this is more a loss of volume than a loss of work, because all the work put in in compressing this air is again given out by expansion. There are several other sources of loss, which can only be remedied by the designers of the compressor and by the makers having only good and reliable workmanship put into the machines. Some of these losses may be caused by the springs being too strong. As a matter of fact, in machines with spring delivery valves there is always 2 or 3 pounds more pressure in the cylinder than is shown by the gauge, caused by the lift of the valve against the spring. Mechanically worked suction valves are now being adopted in most of the larger compressing plants. The delivery valves should likewise be nicely adjusted and of sufficient area. They should immediately open or close according as the piston pressure reaches the receiver pressure or descends below it.

In spite of these drawbacks the use of compressed air for mining purposes is largely on the increase. It has the advantage of not losing either power or volume by condensation during transmission. It can be conveyed into any part of the mine without inconvenience, and readily split up. The exhaust also improves the ventilation in immediate surroundings of the machine, but it is not appreciable many feet away; it also cools down quickly a hot end or rise.

To summarize, a compressor, in order that the speed should not be excessive, should be larger than the requirements.

The pipe line should be of sufficient capacity. There should be a receiver on top in order to cool the air before traveling through the pipes, so that a large percentage of the moisture may settle there instead of in the pipes. A receiver, such as previously described, should be at every level, and nothing but the best of workmanship employed during the construction of the compressor and receiver, and the best of material used.

Having thus got the air at sufficient pressure to be serviceable, we will now consider the methods of its application to our calling as miners. The rock-drill, the air-winch for hauling up inclines and winzes, and the underground locomotive for hauling the ore along the levels, appear to be the principal methods of applying it.

The rock-drill stands out prominently as the most important method of its application. As a self-acting power machine for rock-drilling it is the outcome of the last half century. The first patent for a self-acting percussive rock-drill was taken out by Couch in 1849. This was improved by Fowle, Ingersoll, Rand, Sargeant, and others, until its construction has been brought to its present perfect form. Over 100,000 rock-drills are now in use in mining, tunneling, and quarrying, and this fact alone should prove their usefulness. No modern up-to-date mine is considered thoroughly equipped unless it has its compressor and rock-drill plant, because by their aid the development and work of a mine can be carried on more expeditiously and economically. There are a great number of different makes of machines before the mining public at the present time, and each one claims to be more efficient than the others. I am not prepared at the present time to discuss the qualities of the different drills, but in my opinion the best drill would be the one that is simplest in design and construction, with strength in every part, combined with lightness, in order that there should be a minimum risk of accidents, consequently stoppages of the machine; with a maximum ease in rigging and unrigging. The columns and bars upon which it is rigged should be easily put up or taken down, and should give a wide range to the machine. It should also give the greatest amount of boring footage for the air used. To work drills so that we may have the greatest efficiency—that is, the greatest amount of work out of them for the work put into the compressor—they should, as far as possible, be kept constantly boring, or in other words, should have two or three faces to work, so that as soon as one face is bored out, the machine can be unrigged, and immediately removed and set up in another face. This is the usual practice on Gympie.

The amount of boring that can be done by a machine on Gympie is variously estimated, but at the 2 North Columbia and Smithfield, with a 3½-inch Little Hercules rock-drill, in very hard, semi-crystalline calcerous greywacke, with an average of 70 pounds pressure of air—allowing five hours out of the eight for effective work—after deducting the time required for rigging the machine, changing its position for different parts of the face, changing blunt drills for sharp ones, etc., I find we can bore on an average 35 feet. This would represent, at the average of 250 blows per minute, and 10 blows to make a complete rotation, a cut slightly less than one-sixteenth of an inch. That would be theoretically, but practically the cut would be much deeper, because we know that in starting a hole the full force is not given to the blow, while many blows may be given at the full strength of the stroke. When this is done, there is a certain amount of cushioning by the air; therefore we see that a number of the blows struck are not very effective. I think that from 75 to 80 per cent. of the full stroke of the piston is the most effective length of stroke. Of course, there are many places where much larger footage can be done, but we are all aware that 30 feet in one place might possibly be a great deal better work than 40 feet would be in another; a great deal depends on the class of rock.

It is now being acknowledged that for most cases machine work is much cheaper than hand labor, the harder the rock the more pronounced the difference between the two classes of work. For instance, take the ground above referred to. In stoping, one miner was considered to have done fairly well if he bored from 3 to 4 feet per day. At that rate it would require about 10 men with single-hand hammers to bore as much as one ma-

chine; and at the local rate of wages for both classes of work this would be as £4 3s. 4d. to 19s. 2d. Add to machine rate £2 for compressor and other extra charges, which is a very wide margin, we still have a balance of £1 4s. 2d. per day in favor of the machine. There is another consideration that must not be lost sight of, and that is that one 4-feet machine-hole in a stope will break from 50 to 100 per cent. more rock than two holes 2 feet deep each; therefore we would have, in addition to the saving of £1 4s. 2d. about two-thirds more rock broken. This refers principally to where the rock is hard and tight. There are many places on Gympie where it is cheaper for hand labor to be employed, because the rock is considerably softer; therefore fewer holes could be bored off a rig with a machine, and in an awkward place a good deal of time is taken up in rigging. Two men with hammers could do nearly as much boring and could bring down with their holes as much rock as the timbers can stand. There is also less likelihood of the surrounding rock being loosened, thereby making it safer for the men, which is the principal consideration in mining operations.

The use of air-winches is generally forced upon us by meeting with cross-courses or other dislocators. No manager likes to use them, as they are always a source of expense. Locomotives driven by compressed air are being extensively adopted in large mines, more particularly those that are opened by an adit tunnel, or in coal-mines. There are many other interesting facts in connection with compressed air I would like to speak of, but I think I have trespassed too far already on your good nature, but at some future date, if it is your wish, we may have another chat on this interesting and familiar subject; familiar it ought to be, as without it we would soon cease to exist.

Car Heating by Steam Mixed with Air; Eastern Railway of France.

After an extensive series of experiments, the Eastern Railway of France has adopted a car-heating system in which a mixture of compressed air and steam is used, and this system is described in the November issue of the "Revue Generale des Chemins de Fer" by Mr. Lancrenon, chief engineer of motive power and machinery of the Eastern Railway.

The subject of heating cars from the engine was first taken up in connection with the long suburban trains at Paris, where the use of portable foot warmers was a nuisance, and stoves gave rise to universal complaint. A system of steam heating then in use had iron cylinders in the car with a single opening for the entrance of steam, and the escape of water of condensation. This was not satisfactory and could not be used for trains of over 10 or 12 cars, while the suburban trains have as many as 24 cars, many of them being double-deck cars (with both decks inclosed). The steam-heating system was also objectionable in that it heated the air of the car without warming the feet of the passengers. On considering the problem, Mr. Lancrenon conceived the idea of using a mixture of steam with air from the brake pump and distributing this by a system of pipes with traps or blow-offs at the ends.

Along the whole length of the trains extends a train pipe, the admission of steam and air to which is controlled by the engineman on the locomotive. On each car the train pipe connects at the front end with a chamber from which run three small pipes, which are looped along the floors of the several compartments, and are covered with metal plates, these plates being put in front of the transverse seats, so as to form foot warmers. At the rear end of the car the pipes enter a chamber fitted with a trap to discharge air and the water of condensation. One, two or three pipes may be used, according to the severity of the weather.

With a long steam pipe closed at the ends by a trap, pockets of water are liable to occur and prevent the proper flow of steam to the end of the pipe, but by admitting a certain proportion of compressed air, the rate of flow is increased sufficiently to keep any water moving constantly towards the discharge end. This combination of air and steam has made it practicable to use long pipes of small diameter, laid horizontally, and having numerous elbows. As the car body tilts on curves, etc., these elbows form low points for the collection of water, and this gave rise to considerable trouble when steam alone was used, but since the adoption of the combination

system no trouble has been experienced. Owing to the more rapid current, also, the initial heating of the cars is much more rapid than when steam alone is used.

In a test with a train of 19 cars, the train pipe was charged with steam at 8.8 pounds pressure, and when the pipes were filled and the cars heated the gauge on the train pipe showed 1.65 pounds. All the traps were closed, only a little water escaping, and no steam was visible for the entire length of the train. Air at 8 to 10 pounds pressure was then admitted, and in 30 to 40 seconds the gauge on the train pipe showed a pressure which rose to over 4½ pounds. The traps then opened, discharging water in plenty and some moist air. This lowered the gauge pressure to 3½ pounds, which remained constant. In another test with 30 four-wheel cars (130 compartments), it was not possible to fill the pipes when steam alone was supplied, and air at about 10 lbs. pressure was admitted. When the pipes were all filled and the cars warmed, the air was shut off, and with 4½ pounds steam pressure at the head end, the pressure at the rear end was only 1½ pounds. Air at 10 pounds was again admitted, when the gauge rose to 3⅓ pounds, but when the traps opened it fell to 2¾ pounds.

For the train pipe coupling rubber hose and metallic tubes with flexible joints have been used, but the latter have now superseded the rubber hose. For coupling to the cars of foreign railways, to the train pipes of freight cars run in passenger service (and having no heater pipes), and to the fixed steam pipes for heating trains at stations, a flexible tubing is used composed of spirally-coiled strips of steel. These, however, are inferior to the metal tubing with flexible joints.

Mr. Lancrenon states that the combination heating system above described has been adopted also for the Paris suburban trains of the Western Railway, and for the Paris-Bordeaux trains of the Orleans Railway. The system will be put in service on these lines during the present winter.—*Engineering News.*

Air Spray for Fruit Trees.

In a recent description in the *Rural New Yorker* as to the best means for spraying fruit trees, A. T. Erwin, of the Iowa Experiment Station, writes as follows:

"As to what form of power is best, I would recommend some type of machine using compressed air. From our experience this type of machine is simpler in operation, and more satisfactory than gasoline. These machines are operated upon a very simple and effective principle. A sprocket is attached to the rear wheel and a chain connects this with an air pump which forces air into a small storage tank or receiver. In driving to the orchard a pressure upwards of 150 pounds is readily formed, and this gives a steady, even pressure, a finely divided spray and a uniform flow and distribution. In the spring the ground is usually soft, and the load should be as light as possible. An equipment of this kind will add about 300 pounds additional to the load. The lightest type of gasoline engine with which I am acquainted weighs double this amount. Some of them are also upright in position and tend to make the load topheavy, and are inconvenient to use on steep hillsides. In my experience the gasoline engine requires a good solid foundation or base to rest upon. It is very apt to prove whimsical and go on a strike almost any time on a spray tank. Steam sprayers I never used.

"The second question. how many fruit trees should a farmer have in order to justify him in buying a power sprayer, is not easily answered. I can reply to this best, perhaps, by indicating the capacity of this type of machine, and its comparison with a hand pump will indicate its profit, and hence enable him to answer for himself as to which he can use to better advantage.

"Last spring the horticultural department of the Iowa Experiment Station purchased a sprayer which is operated upon compressed air principles already described. A pressure of 80 to 100 pounds did excellent and rapid work. A part of the time the ground was soft, and it was necessary to attach the mud claws to prevent the wheels slipping when the pressure ran high. The orchard in which this machine was used contained 70 acres, the original planting being 25 years old, and planted two rods apart. About 10 years later the interspaces were filled in one way with apple and plum trees. The season was an unusually wet one and the land hilly, and under these conditions our best

record was 12 acres per day of 12 hours' work. Two men did the work, one man driving and operating one line of hose. Both sides were sprayed at the same time. Sufficient power was maintained once the tanks were charged in driving from tree to tree to do the work. The five-barrel tank proved too heavy for the soft ground and in a hilly country. Were we purchasing again I should secure a three-barrel capacity tank instead.

"I believe that a compressed air sprayer can cover from one-half to two-thirds more ground than a hand machine, and do it much better. The spray is more finely divided, which increases its efficiency, hence requires less material, and the ground is covered very much more rapidly. I should estimate that the grower of 20 acres, or perhaps less, would profit by the expenditure in this type of machine."

Notes.

The January issue of *Cassier's Magazine* contains a description of the Chamonix Electric Railway in Switzerland. In the description of the cars it is explained that the power for working the compressed operating gear and also for the brakes is derived from a motor-driven air compressor in the luggage compartment behind the driver.

The Post Office Department at St. Louis, Mo., expects to have a new and complete pneumatic tube service installed by February 1. This pneumatic tube system promises to attract more than the usual attention, as it will be in operation during the St. Louis Exposition and, therefore, will be seen by people from all over the world.

Another application of the pneumatic hammer has been made in England, where it has been tried successfully for breaking up roads which have heretofore been absolutely pulled to pieces by hand labor. The chisel was fitted into an ordinary pneumatic hammer, the piston of which made 400 strokes per minute. By means of an air cushion the recoil was practically overcome. The power was produced by a motor-driven compressor.

The North-Eastern Railway Company has introduced a large installation of electro-pneumatic signalling on its Sunderland and North Shields line at Harton Colliery. This is the first instance of its adoption for the passenger traffic of the North-Eastern Railway. In order to ascertain the relative merits of the three power signalling systems now engaging the attention of British railway officers, the North-Eastern Company will shortly lay an experimental installation of low-pressure air signalling at Paragon Station, Hull.—London (Eng.) *Daily Globe.*

In an article on "The Limits and Possibilities of Deep Mining," by E. H. Robertson, in the European edition of the *Engineering Magazine*, Mr. Robertson says:

"The use of compressed air machines and drills in the mine is of much value in reducing the heat, and no doubt this will be an important factor in favor of the adoption of compressed air rather than electricity in deep mining. Liquid air has been suggested as a means of replenishing quickly the atmosphere in the working place and may ultimately prove of value."

The efficiency of compressed air in operating pumps underground in mines is greatly increased by reheating the air at a point near the pumps. This is usually possible where the ventilation is sufficiently good. A compound direct-acting pump, heated sufficiently to prevent freezing, will pump double the amount of water with the use of a given amount of air that a single-acting pump will. Freezing of a mine pump may often be prevented by arranging a drip from a pipe so that a small stream of mine water will fall upon the exhaust opening. This usually keeps the temperature at a point somewhat above freezing. A large exhaust opening is also necessary, and may be kept from clogging with ice much easier than a small one.—*Pacific Coast Miner.*

Particularly complete is the mechanical plant at the Broadway-Maiden Lane Building, New York. The compressed air equipment is of a somewhat unusual

nature. Two Westinghouse locomotive type compressors are mounted on the wall in the elevator pump room and serve to supply air needed for the pressure tanks of the heating system, and for cleaning purposes. The compressors are arranged to work in parallel or in series, as desired, and are connected with a receiver 5 feet high and 24 inches in diameter. A line of piping is carried in the elevator wells to a point near the ninth floor, and to this outline is connected 150 feet of hose, so that all parts of the elevator well above and below can be reached and the grill work readily cleaned, which is done once a week. Compressed air is also used for blowing off the dust on the blower tubes, this being done about twice a week.

In the building of the Williamsburg Bridge across the East River, connecting two of the boroughs of Greater New York, compressed air has proved invaluable for operating the riveters. There were 22 riveting gangs of four men each, which drove an average of 150 rivets per gang in eight hours. About 25 per cent. of these rivets are 1 inch in diameter and nearly all the remainder are 7/8 of an inch. They were driven by Philadelphia and Cleveland pneumatic hammers, operated by air at 100 pounds pressure. The air was compressed by a 200-H. P. Ingersoll-Sergeant compressor plant at the Brooklyn approach, which also supplied air for riveting the upper part of the New York approach. The delivery pipe was 6 inches in diameter with a two foot expansion loop at each quarter point of the main span. It was reduced to 2½ inches diameter at the New York approach and was provided with 2-inch tee bolts and manifolders with four connections for flexible hose at points about 50 feet apart.

A compressed air haulage plant has recently been installed by the Encampment Smelting Company at its mine at Rudefeha, Carbon County, Wyo. The locomotive is of the H. K. Porter type, with cylinders 5 inches by 10 inches and capable of hauling a load of 25 tons on a 2 per cent. grade, which is the heaviest in the mine. This tunnel is about 2,000 feet long, the grade sloping from the mine to the ore bins on the outside. The power is supplied by a Norwalk compressor with a capacity of 65 cubic feet of free air per minute, compressing to 850 pounds. The compressor is belt-driven from a Buffalo self-contained automatic engine.

Compressed air for the rock drills is supplied by a Laidlow Dunn-Gordon duplex compound compressor with Meyers cut-off valve gear, which is also located in the power house. Twenty-five rock drills of the Sullivan type, with 2¾ inch and 3¼ inch cylinders, are used in the different levels and stopes. It is expected in the near future to install a diamond drill equipment which will also be operated by compressed air.

At the power-house No. 2 of the Niagara Falls Power Company compressed air is used to operate the brakes for the turbines and also for cleaning purposes. To supply the compressed air a two-stage Ingersoll-Sergeant air compressor is located in a special lateral chamber at the bottom of the well-pit. It is driven by a Pelton water wheel 7 feet in diameter, which is fed from a 36-inch steel main. The wheel is designed to develop 38 horse-power at 120 revolutions per minute and under a head of 127 feet. The compressor has a capacity of 120 cubic feet of free air per minute compressed to 140 pounds per square inch. The air pressure desired is maintained automatically by controlling the air inlet and the flow at the nozzle of the Pelton wheel. The system contains a receiver 4 feet in diameter and 8 feet high, located at the turbine. A system of pipe extends to each chamber so that hose may be attached for conducting the air as desired. A smaller plant is located at Power House No. 1, and arrangements are made so that the two may be connected if necessary.

There seems to be some question as to who was the originator of the scheme of painting the buildings of the World's Fair with the assistance of compressed air. The Boston *Sunday Globe* recently published a portrait of Frank D. Millet, the artist, who was born at Mattapoisett, Mass., November 3, 1846. Concerning Mr. Millet's connection with this work, the *Globe* says:

"He had charge of the art work of the World's Fair at Chicago, and when the question of painting the building came up it was found there was not time enough to do it in the regular way, so he invented a machine to do the job.

"He took a gas pipe about a foot long, pounded flat at one end so as to leave an opening about an inch across and wide enough to insert a sort of perforated cardboard. This he attached to a long piece of hose, the other end of which he dipped into a barrel of paint. An electric motor then pumped air and paint through the hose. The force of the air scattered the paint in a fine spray.

"It worked like a charm and the work was done on time. This method has since become popular in painting shops, etc. It does the work of forty or more painters."

A remarkable piece of engineering was completed in September in Cranston, R. I. The chimney of the Narragansett Brewery, 192 feet in height, owing to undermining by water, was so badly out of plumb (leaning nearly four feet toward the east) that its falling seemed assured. The fate of an $8,000 chimney seemed to be imminent and certain. J. H. Gerhard, civil engineer, of Cranston, R. I., undertook to straighten this rival of the leaning tower of Pisa. The plan devised by Mr. Gerhard was a simple one. One course of bricks three-quarters of the way through the chimney was removed from the west side, and its place was taken by wedges of oak. An 8-foot bed of concrete was then laid against the foundation on the east side. Two holes were cut in the east side of the chimney, and in these were inserted 22-inch steel beams 25 feet in length. These were used as levers to tip the 192-foot chimney toward the west. The wooden wedges were gradually burned out by a gas flame driven into the oak by compressed air. The chimney, as the wood was burned away, gradually approached the perpendicular line, the movement averaging about 6 inches a day. When the chimney was straight, the space occupied by the brick was filled and the steel beams were buried in concrete after the removal of the jack screws. This has obviated the necessity of moving the boiler house to another location.—*Brick.*

Another pneumatic power hammer has been placed on the English market by the makers, the William Graham & Sons Engineer Company, of London. This hammer is made in various sizes and is specially designed to deal with light and heavy forgings in iron or steel. The hammer head or ram has a rectangular section and has no piston rod, which is replaced by the ram itself, the object being to obviate any possibility of breakage of piston rods through crystallization. The head is lifted up by the exhaust in the cylinder and is driven down by compressed air. The force of the blow is regulated by a rotary cut-off valve which controls the admission of the air to the cylinder. This valve is oscillated by a lever moving over a mark to indicate whether the valve is open or shut. A second or controlling lever is provided for controlling the piston valve. This second or controlling lever is lifted to its uppermost position and the recording lift is moved to shut. Then the air is exhausted from the cylinder and the head drawn up and held stationary. By opening the regulating valve according to the desired force of the blow and then moving the controlling lever to its horizontal position, the hammer head is set in motion and gives blow after blow until the controlling lever is put back in its former position. The combined vacuum and compression pump is separated from the main hammer so that the hammer may be placed in any position irrespective of the location of the driving power, the required connection being made by cast iron, wrought iron or flexible piping.

In a paper "Railroad Shop Tools," which appeared in the December number of the *Railway Master Mechanic*, Chas. H. Fitch refers to the Kennedy pneumatic bull dozer or "pneumatic blacksmith" as a favorite tool at the Burnside shops of the Illinois Central Railroad. This machine is made by the Featherstone Foundry and Machine Company, of Chicago. It has a great range of work and is said to combine heavy power with quick action. It has been used to make boiler braces, valve yokes, wrecking chain hooks, heavy equalizing beams and all other forms that can be produced with a two-cam press.

The resisting frame extends like the head of a T so as to give place for a large die. There are two cylinders giving ramming movements in two directions at right angles, an end upsetting and a side closing movement. The turning of an air cock applies the rams, while their with-

drawal is governed by another. The claim is made that the dies can be changed in three minutes, ready for new work even of a complicated character. The strokes are adjustable to any requirement. The dies are of two kinds, one coupled to the piston rod of the main cylinder and the other in the form of gripping or forming blocks operated by the lower cylinders.

By placing liners over the face of the dies in forming pipe clamps, 25 different sizes of clamps have been forged in one minute. A valve yoke has been forged in five minutes and a locomotive main rod strap weighing 236 pounds in 47 seconds. Rollers are used at the corner of the dies which facilitates the movement and justification of the work. The usual air pressure carried is 125 pounds per square inch. These forging machines are made with cylinders 16 inches, 20 inches and 24 inches in diameter.

New York theatre-goers have been attracted by Mr. Proctor's ingenious method of outlining the policy at his theatres. The Proctor plan, he calls it, and explains it as follows:

"The Proctor plan just consists in taking care of the Proctor audiences at the Proctor theatres; that is to say, it is a part of the Proctor plan to furnish each auditor with a clean, wholesome show and plenty of it; with courteous attention from the moment one enters the door until one leaves it; with pleasant and agreeable surroundings for old and young, and finally to leave all comers with the impression that they have received more than their money's worth, which in all cases is really a fact."

This doubtless explains how the Proctor playhouses are getting such a large share of patronage.

Our supply of copies of "Compressed Air" for November, 1902, is exhausted and we still have a demand for them for binding. Readers of this paper who have copies of this number which they do not care to preserve will confer a great favor upon the editor by mailing them to "Compressed Air," 26 Cortlandt Street, New York. We shall be glad to pay the regular price for them.

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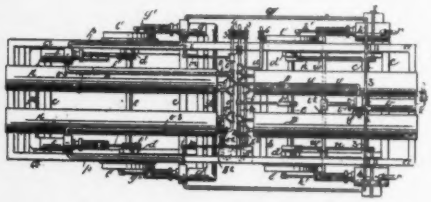
U.S. PATENTS GRANTED DEC., 1903.

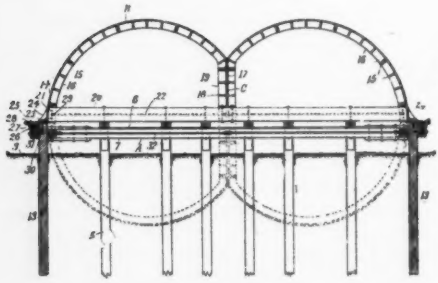
Specially prepared for COMPRESSED AIR.

745,373. UTILIZATION OF COMPRESSED AIR. Robert Nutty, New York, N. Y. Filed Dec. 17, 1898. Serial No. 699,600.



An engine, one or more operating-tanks connected directly to said engine, and adapted to contain propulsive gas or fluid under pressure, in combination with one or more auxiliary or feed tanks adapted to contain a similar gas or fluid under a higher initial pressure than that in the operating-tanks, and a body of water contained in the said auxiliary tanks; a valved pipe connecting the operating and the feed tanks; whereby the gas or fluid withdrawn from said operating-tanks to run said engine is replaced by water from said feed-tanks; and means for heating said water during its passage through said pipe; substantially as described.

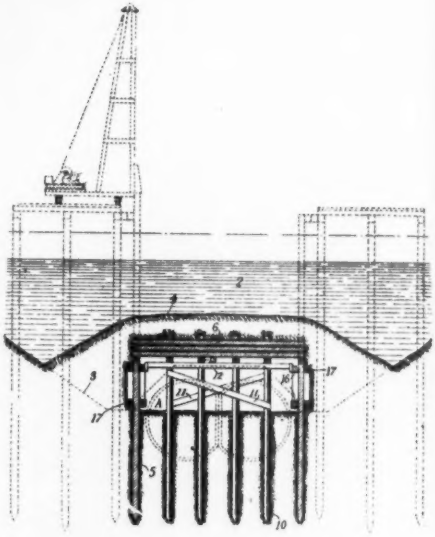
745,456. SUBAQUEOUS TUNNEL. Duncan D. McBean, New York, N. Y. Filed Oct. 22, 1903. Serial No. 178,054.



In tunnel construction, a subaqueous working-chamber, comprising the tunnel roof and walls surrounding the site.

The method of building a tunnel under water, consisting in driving foundation-piles along the site, and impervious sectional walls around the same to bed-rock or to a depth lower than the bottom of the tunnel or its foundation when completed, then cutting off said piles and walls at a depth below the top of the tunnel when completed, then seating the previously-constructed roof thereon in permanent position, then unwatering the chamber so formed, then excavating the necessary material and completing the tunnel within the same.

745,457. SUBAQUEOUS TUNNEL. Duncan D. McBean, New York, N. Y. Filed Oct. 28, 1903. Serial No. 178,950.



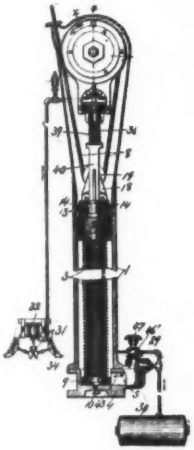
A subaqueous tunnel structure having partially-inclosing side walls secured or anchored thereto and seated on bed-rock or penetrating other material to a depth below the tunnel structure.

745,501. VALVE. Wilhelm Kuhlmann, Offenbach-on-the-Main, Germany. Filed Jan. 14, 1902. Serial No. 89,838.

745,502. COMBINED TROLLEY AND AIR-BRAKE CONTROLLER. James Kynoch, Toronto, Canada, assignor, by mesne assignments, to International Trolley Controller Company, Buffalo, N. Y., a Corporation of New York. Filed Apr. 20, 1903. Serial No. 153,522.

In combination with a trolley-arm-operating cord, mechanism operatively connected to the

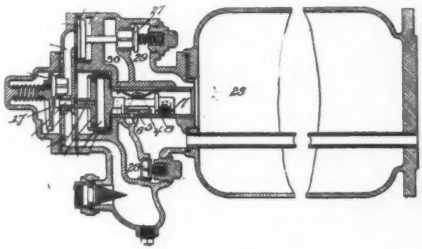
cord and brought into action by a sudden tensioning of the cord whereby the trolley is drawn from the wire, a conduit for compressed air connected to return the mechanism to its normal position, and manually-operated means for controlling the flow of compressed air through the conduit.



A cylinder and a piston movable therein, a valve-chamber having inlet and exhaust ports and communicating with the cylinder, a valve normally closing the inlet and adapted to be operated manually to close the exhaust-port, whereby when the inlet is opened the exhaust-port is closed and *vice versa*, a spring operatively connected to move the piston in one direction, a detent for holding the piston against the action of the spring, a trolley-arm-operating cord operatively connected to trip the detent when the cord is suddenly tensioned, and a compressed-air conduit connected to the inlet and whereby when the valve is open the compressed air returns the piston against the action of the spring.

745,735. AIR-BRAKE. Milton H. Neff, Watertown, N. Y., assignor to New York Air Brake Company, a Corporation of New Jersey. Filed May 21, 1903. Serial No. 158,136.

The combination with the train-pipe, auxiliary reservoir, and brake-cylinder of an air-brake apparatus; of a train-pipe vent-valve for permitting air to escape from the train-pipe; a brake-cylinder supply-duct from the auxiliary reservoir to the brake-cylinder, and valve controlling said duct; and means actuated by the air escaping from train-pipe when vented for actuating said valve in the brake-cylinder supply-duct; and a motor-piston for the train-pipe vent-valve exposed

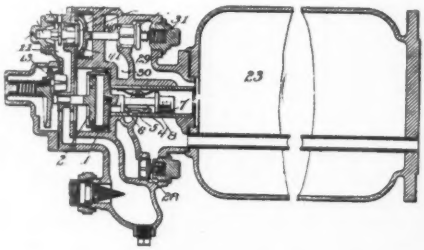


to train-pipe pressure on one side and to pressure of air confined in a small chamber at the other side; a duct connecting the said small chamber with the space containing train-pipe air; and means for closing said duct in response to a sudden reduction in train-pipe pressure.

745,827. VALVE. Ernest B. Hack, Denver, Colo., assignor to the American Filter Press Extraction Company, Denver, Colo., a Corporation of Colorado. Filed Jan. 19, 1903. Serial No. 139,713.

745,878. PNEUMATIC-TIRE PROTECTOR. George E. Mentel and Simon N. Mentel, Springfield, Ohio. Filed Oct. 1, 1903. Serial No. 175,281.

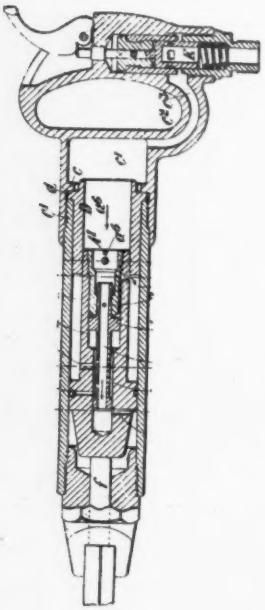
745,934. AIR-BRAKE. Charles W. Valentine, Watertown, N. Y., assignor to New York Air Brake Company, a Corporation of New Jersey. Filed May 21, 1903. Serial No. 158,122.



The combination with the train-pipe, auxiliary reservoir, and brake-cylinder of an air-brake apparatus; of a train-pipe vent-valve for permitting air to escape from the train-pipe; a brake-cylinder supply-duct from the auxiliary reservoir to the brake-cylinder and valve controlling said

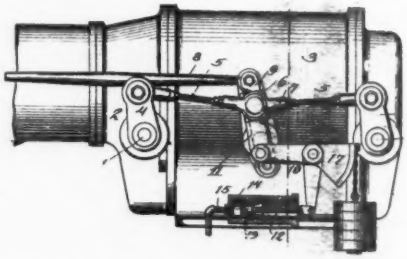
duct; means actuated by the air escaping from the train-pipe when vented for actuating the valve in the brake-cylinder supply-duct; and means for entrapping a portion of said escaping train-pipe air, whereby the valve in the brake-cylinder supply-duct is retained open after the flow of air from train-pipe has ceased, substantially as and for the purpose described.

745,900. PNEUMATICALLY-OPERATED PERCUSSIVE TOOL. Walter Payton, Richmond, England. Filed Apr. 7, 1903. Serial No. 151,540.



A pneumatic percussive tool, the combination with the casing constituting the working cylinder, of a piston, a sliding tubular valve in said piston, the forward end of which is of a greater diameter than its rearward end and is constantly exposed to the pressure of the motive fluid, an enlargement or collar on said valve working in a chamber in the piston and having its forward side constantly open to the exhaust-chamber and means whereby the rearward side of said collar is subjected to the fluid-pressure when the piston is at one end of its stroke and is open to the exhaust when the piston is at the opposite end of its stroke for the purpose specified.

746,032. VALVE OPERATING AND CONTROLLING MECHANISM. Hugh V. Conrad, New York, N. Y., assignor to Rand Drill Company, New York, N. Y., a Corporation of New York. Filed Feb. 26, 1902. Serial No. 95,690.



An air-compressor, the combination with a cylinder of reciprocating admission-valves arranged in their reciprocation to alternately admit fluid for compression to opposite ends of the cylinder, and a rocking operating-lever for transmitting such reciprocating movement to said valves, of links normally connecting said valves to said rocking lever at a point therein having the necessary throw to produce the aforesaid reciprocation, and means for shifting the point of such connection to a point nearer the center of oscillation of said rocking lever, at which point the valves will not receive an operative throw.

746,107. AIR-BRAKE SYSTEM. Harry R. Kuhn, Homestead, Pa. Filed Mar. 16, 1903. Serial No. 147,969.

A device of the character described, the combination of the valve-body and rotarily-mounted part therein having an eccentric portion adapted to operate within an opening on an extension of the valve contained therein, and the eccentric part being so positioned that in one position said valve is permitted to close and in the other position said valve is not permitted to close.

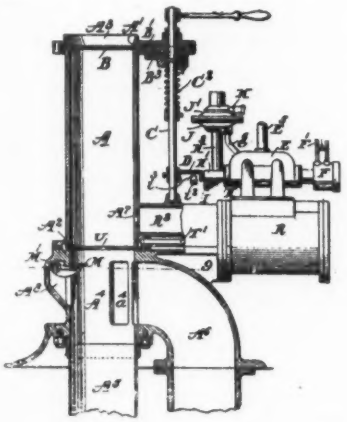
746,207. REPAIR DEVICE FOR PNEUMATIC TIRES. John R. Vosburgh, Johnstown, N. Y. Filed Sept. 10, 1903. Serial No. 172,635.

746,279. PNEUMATIC SEAT-POST FOR BICYCLES. Edward Brougham, Brandon, Canada. Filed Sept. 2, 1902. Serial No. 121,765.

A pneumatic-cushion saddle-post comprising an outer tubular member closed at one end, a post telescoping within said outer member, and a cylindrical capsule interposed between the inner end

of the inner member and said closed end of the outer member, and having a tubular air-valve projecting concentrically through a hole in the latter, whereby a pump may be externally applied, said capsule having a rigid head at its other end and resilient sides.

746,266. SENDING DEVICE FOR PNEUMATIC TUBES. Birney C. Batcheller, Philadelphia, Pa. Filed Oct. 11, 1900. Serial No. 32,682.



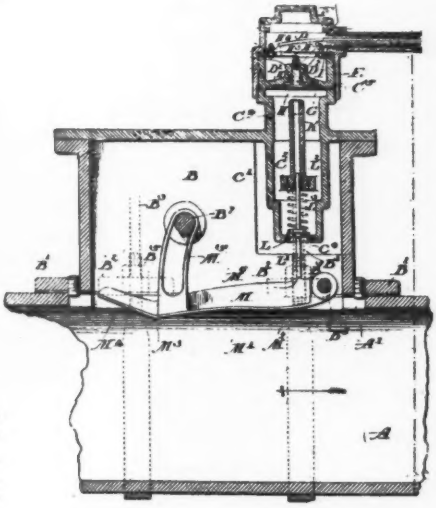
A sending device for a pneumatic-tube system, a tube-section A in registry with the end of the despatch-tube in combination with an end gate and an inner gate for closing the tube-section, means for first admitting compressed air to the tube-section and then opening the inner gate arranged to be set in operation by the closing of the end gate, an automatic lock arranged to prevent the opening of the inner gate when engaged, a time escapement arranged to disengage said lock a determined time after the inner gate has closed after opening, and means for first closing the inner gate and then opening the end gate arranged to be set in operation by the exit of a carrier from the tube-section.

746,545. VALVE. Siegfried Mertens, Charlottenburg, Germany. Filed Nov. 24, 1902. Serial No. 132,618.

746,651. PNEUMATIC LAYING-OFF APPARATUS FOR CYLINDER PRINTING-MACHINES. Wilhelm M. Rockstroh, Klein Sedlitz, Germany. Filed Apr. 16, 1902. Serial No. 103,216.

A pneumatic laying-off apparatus for cylinder-presses comprising oscillating levers, a suction-pipe carried thereby and provided with apertures, and a series of rings adjustably mounted on the pipe and provided with apertures adapted to register with the apertures of the suction-pipe, a shaft passing through the pipe, pinions on said shaft and segmental racks carried by the arms and with which racks the said pinions engage.

746,267. PNEUMATIC-DESPATCH APPARATUS. Birney C. Batcheller, Philadelphia, Pa. Filed Mar. 29, 1901. Renewed Apr. 23, 1903. Serial No. 154,028.



In a pneumatic-despatch system, a pivoted finger normally extending into a pneumatic tube and having its carrier-containing face M formed as described to impart to the finger under the pressure.

746,884. VALVE. Alonzo Sharp, Troy, N. Y., assignor to Adams Laundry Machine Company, Troy, N. Y., a Corporation. Filed Apr. 12, 1902. Serial No. 102,511.

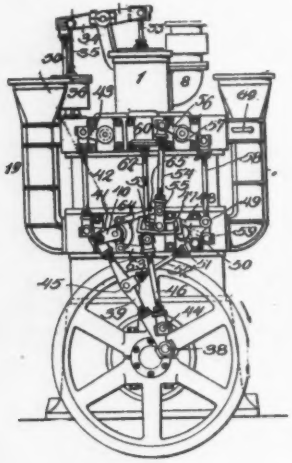
746,955. VALVE. Lyman O. Goodwin, North Andover, Mass., assignor of one-half to George L. Wright, North Andover, Mass. Filed Apr. 26, 1901. Serial No. 57,589.

746,969. SAFETY DEVICE FOR AIR-BRAKES. John H. Luckey, New York, N. Y. Filed July 15, 1903. Serial No. 165,634.

A safety device for air-brake apparatus, comprising a branch pipe communicating with the

train-line pipe and with the atmosphere, said branch pipe having a valve interposed in its lower portion and seating in opposition to the pressure of the air in the branch pipe, and a lever connected with said valve and solely depressible by a foot-pedal.

746,745. VALVE-GEAR FOR FLUID-COMPRESSORS. Francis M. Rites, Ithaca, N. Y., assignor to Ralph Baggaley, Pittsburg, Pa. Filed Mar. 5, 1903. Serial No. 146,363.



A fluid-compressor, the combination with a discharge-valve, a link, a sliding block thereon and means connected to said block for operating said valve, of a movable guide for said link pivotally connected to it, means for oscillating said link about its guide, other means for moving said guide during the oscillation of the link, and automatic fluid-pressure-governing means, actuated by variation in relation of pressure reached in the compressor to pressure of the receiver, for adjusting the position of the block on the link.

A fluid-compressor, the combination with separate admission and discharge valves, separate wrist-plates for said admission and discharge valves, and means for driving said valves from their respective wrist-plates, the means for driving the discharge-valves comprising valve-arms, and rods connecting said arms to points on the discharge-valve wrist-plate which move in directions approximating right angles with respect to their respective rods, during closed positions of the corresponding valves, and in directions approximating parallelism with respect to their respective rods, in open positions of the corresponding valves, of mechanism for driving said wrist-plates comprising a crank-pin, a pitman therefor, and means connecting said pitman to each of said wrist-plates.

747,124. PNEUMATIC ELEVATOR. Chester Bradford, Indianapolis, Ind. Filed June 9, 1902. Serial No. 110,814.

The combination, in a pneumatic elevator, of two conductor portions, one of which extends from and forms a continuation of the other but at an angle therewith whereby a change of direction is secured, a telescopic elbow composed of two portions and uniting said two conductor portions whereby the angle between them may be varied, a turn-table carrying one elbow portion, a swinging frame pivotally mounted on said turn-table and carrying the other elbow portion and also carrying the conductor portion which is adapted to be varied in position, a trussed mast extending up from said turn-table, a stay-brace extending from the mast-truss strut to the turn-table arms, and a tackle running from said mast to and supporting the conductor portion carried by the swinging frame.

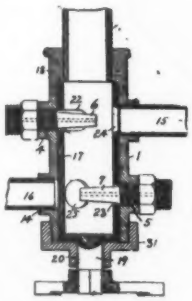
747,251. PNEUMATIC STRAW-STACKER. Harry W. Smith and Martin F. Smith, Glanford township, county of Wentworth, Canada, assignors, by direct and mesne assignments, to the Indiana Manufacturing Company, Indianapolis, Ind., a Corporation of West Virginia. Filed Dec. 5, 1901. Serial No. 84,819.

A pneumatic stacker, a fan, in combination with a fan-housing located at one side of the end of a machine; a slanting board hinged to the side of the machine and extending over to the inner side of the top of the housing; and a triangular piece fitted underneath the forward end of the said board to close off the space between it and the fan-housing, substantially as described.

A pneumatic stacker, a substantially vertical pipe divided into two parts sleeved one within the other, in combination with a circular track or ring surrounding the upper part of the pipe; means for supporting the said track or ring from a stationary part of the apparatus; a ring connected with and encircling the upper part of the pipe; one or more rollers journaled at one side of the said ring and engaging the upper side of the track; one or more rollers journaled at the other side of the said ring and engaging the under side of the said track; an elbow formed of telescopic sections formed at the upper of the two parts of the discharge-pipe and bending outwardly above the rollers engaging the upper side of the track; means connected with the ring

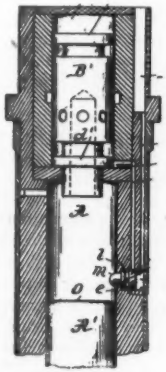
secured to the pipe for collapsing or extending the elbow, substantially as described.

747,308. PNEUMATIC TRACK-SANDER. James W. Thomas, Baltimore, Md., assignor to John J. Morgan, Baltimore, Md. Filed Sept. 17, 1903. Serial No. 173,522.



A pneumatic track-sander comprising a casing having an opening for communication with the sand-reservoir, an opening for communication with the forward sand-discharge pipe, an opening for communication with the rear sand-discharge pipe, and two openings for communication with the two air-delivery pipes; a sleeve fitted in the said casing and having two ports adapted to register with the sand-discharge pipes; and means for rotating said sleeve.

747,336. PNEUMATIC TOOL. William H. Soley, Philadelphia, Pa., assignor, by mesne assignments, of one-half to Thomas H. Dallett Company, Philadelphia, Pa., a Corporation of New Jersey. Filed Aug. 1, 1902. Serial No. 117,934.

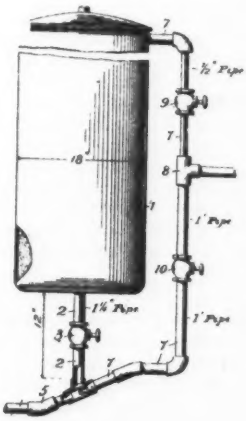


A pneumatic tool, in combination, with the piston-chamber and piston therein and valve-chamber and valve therein, of a lateral passage opening into the piston-chamber at the upper portion thereof, a passage connected with the air-supply and a passage from the valve-chamber opening into said lateral passage, an auxiliary valve in said lateral passage, said auxiliary valve having a passage in constant communication with the live air, circumferential-grooved-portion orifices in said portion extending into said passage and a projecting portion adapted to extend within the piston-chamber, said auxiliary valve being moved in one direction by the live air and in the other direction by the piston in its movement.

747,001. PNEUMATIC TIRE. Edward H. Seddon, Brooklands, England. Filed Mar. 17, 1903. Serial No. 148,160.

747,339. VALVE. William Wright, New York, N. Y.; Mary E. Wright, administratrix of said William Wright, deceased. Filed Mar. 19, 1903. Serial No. 148,472.

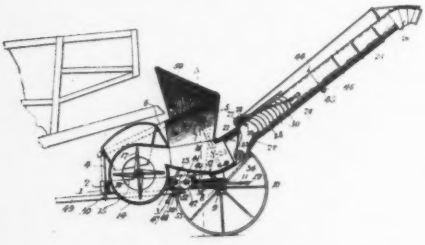
747,396. SAND-BLAST APPARATUS. Neal Farnham, Chicago, Ill. Filed Apr. 10, 1903. Serial No. 151,998.



A sand-blast apparatus comprising the tank, the discharge-pipe leading from it, to the sand- carrying hose, the compressed-air-supply pipe opening into the upper part of the tank and having the

upper and lower controlling-valves, the inclined coupling between the sand-carrying hose, the compressed-air-supply pipe and the discharge-pipe from the tank, and the air-blast nozzle having its point of discharge in the inclined coupling beneath the mouth of the discharge-pipe from the tank, substantially as described.

747,397. PNEUMATIC STRAW-STACKER. Samuel D. Felsing, Crookston, Minn. Filed Mar. 5, 1903. Serial No. 146,373.



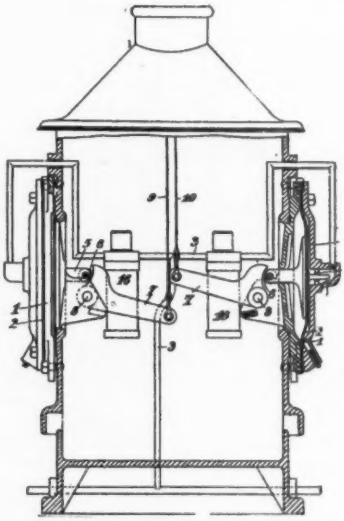
A pneumatic straw-stacker, the combination of a hopper, means for forcing a blast of air into said hopper, and an extension forming an air-trunk connected flexibly with said hopper, the latter and the air-trunk having segmental, overlapping parts concentric with the pivot whereby said parts are connected.

747,468. VALVE. Joseph W. Nethery, Indianapolis, Ind., assignor to the Nethery Hydraulic Valve Company, Indianapolis, Ind., a Corporation of New Jersey. Filed Nov. 8, 1901. Serial No. 81,545.

747,551. AUTOPNEUMATIC MUSIC-PLAYING INSTRUMENT. George W. Haywood, Meriden, Conn., assignor to Wilcox & White Company, Meriden, Conn., a Corporation of Connecticut. Filed June 1, 1903. Serial No. 159,450.

In combination, for the purpose set forth, a wind way-passage, means for inducing a wind-current therethrough, a valve for controlling said passage, a regulator-pneumatic device internally communicating with said windway-passage, and having a movable member with a connection for moving said valve, a tension-spring for said pneumatic, and an extraneous operating means connected with said pneumatic for temporarily applying force thereto in accord with or in opposition to the normal action of the tension-spring.

747,432. PNEUMATIC RAILWAY SIGNALING APPARATUS. Ernest C. Irving, Westminster, England, assignor of one-half to John Patrick O'Donnell, Westminster, Middlesex county, England. Filed Apr. 3, 1903. Serial No. 150,959.

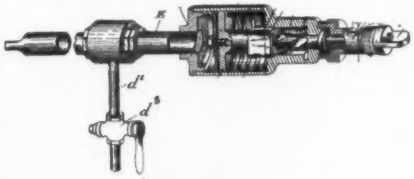


In pneumatic railway-signaling, a flexible diaphragm, a casing inclosing said diaphragm and adapted to be attached to a signal-post, a plate and (or) rod in operative connection with the diaphragm, guides for said rod in the casing, a friction-roller on one end of said rod, a lever pivoted on the diaphragm-casing, one end of said lever being adapted to be operated on by the friction-roller, a wire connecting the other end of said lever to the signal-arm, and means for admitting the motive fluid to and exhausting it from the diaphragm, all substantially as described with reference to the drawings annexed.

747,565. PNEUMATIC FLUE-CUTTER. John T. McGrath, Fort Gratiot, Mich. Filed Sept. 5, 1902. Serial No. 122,235.

A flue-cutter, the combination with the casing having a radially-movable cutter, of a spindle rotatably mounted in the casing, adapted when rotated to force said cutter outwardly, a reciprocating piston within the casing, and means whereby the reciprocation of the piston imparts rotary movement to said spindle, substantially as described.

A flue-cutter, the combination with the rotatable casing, the central spindle extending therethrough and having spiral grooves formed therein and a cutting wheel adjusted and supported by the spindle, of a cylinder attached to or forming part of the casing and having an air-inlet pipe and an outer rectangular recess, a piston located within the cylinder and provided with a stem having a rectangular end having a central orifice designed to receive the spiral-grooved end of the spindle, balls located in the spiral grooves and set-screws designed to extend through the square portion of the stem and having cup-shape inner ends designed to receive and hold the balls in position and a spring located between the piston and the end of the cylinder, as and for the purpose specified.



747,599. SELECTIVE DEVICE FOR PNEUMATIC-DESPATCH TUBE SYSTEMS. Edmond A. Fordyce, Chicago, Ill. Filed Feb. 14, 1902. Serial No. 94,143.

A despatch-tube system, the combination with a main tube and a series of branch tubes leading therefrom, of switches located at the junctions of the several branch tubes with the main tube, pivoted triggers disposed across the path of travel of the carriers in advance of said switches, pivoted tripping-levers disposed alongside said triggers and having projections extending to varying distances beyond the transverse planes of the triggers, switch-operating arms pivoted to and advanced by said tripping-levers into engaging relation to their respective switches, connections between the triggers and their respective switch-operating arms for raising the latter, and a series of carriers having graduated holes in their heads to co-operate with the graduated projections of the tripping-levers, substantially as described.

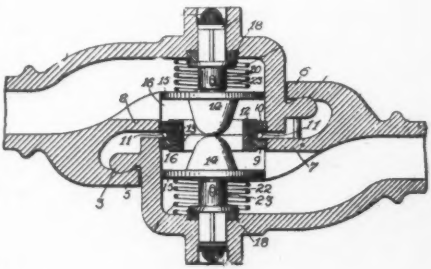
747,656. PRESSURE-RETAINING VALVE. Francis P. Skeffington, Spokane, Wash. Filed Aug. 3, 1903. Serial No. 168,055.

An air-brake system, the combination with an automatic pressure-retaining valve connected to the auxiliary reservoir and the triple-valve exhaust, of a bleed-valve controlling and in communication with the pressure-retaining valve and the auxiliary reservoir.

747,724. AUTOMATIC SWITCH. Oliver Jordan, Lowell, Mass. Filed Oct. 10, 1903. Serial No. 176,551.

A device of the class described, the combination with a main duct, of a branch duct leading therefrom, a normally closed and locked switch disposed between said ducts, means operable by a carrier for releasing the switch, and means for automatically opening the switch.

747,733. COUPLING FOR AIR-PIPES. Harry C. Lafferty, Allegheny, Pa. Filed Sept. 24, 1903. Serial No. 174,395.

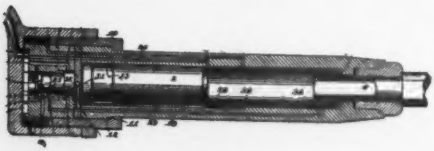


A coupler comprising two sections formed with alining openings, a gasket carried by each of the sections extending in said openings and having their outer faces in engagement with each other, a valve arranged in each of said sections, the opposite faces of said gasket forming seats for said valves, auxiliary valves carried by the stems of the first-named valves, with ports arranged in alinement with said openings, said auxiliary valve closing said ports, and foraminous caps at the outer ends of said ports.

747,751. PNEUMATIC HAMMER. Albert C. Murphy, East St. Louis, Ill., assignor to Standard Railway Equipment Company, a Corporation of Illinois. Filed May 17, 1901. Serial No. 60,693.

A pneumatic hammer comprising a cylinder having ports for the admission and release of air,

a piston in said cylinder and a valve for controlling the admission and release of air, said valve being of the differential-piston type and having its smaller end exposed to constant pressure and having a groove in its smaller diameter arranged to communicate at all times with a main

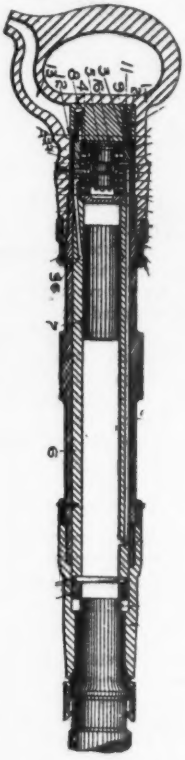


release-port and to communicate alternately with the respective ends of the cylinder, the cylinder having a supplemental exhaust-port located in the forward portion thereof in position to be uncovered by the piston shortly before the completion of its return stroke, and said piston having also a port communicating with the larger end of the valve-chamber and arranged to be uncovered by the piston simultaneously with the supplemental exhaust-port, substantially as described.

747,752. PNEUMATIC HAMMER. Albert C. Murphy, St. Louis, Mo., assignor to Standard Railway Equipment Company, a Corporation of Illinois. Filed Sept. 16, 1901. Renewed Nov. 2, 1903. Serial No. 179,636.

A pneumatic hammer having ports for the admission and release of pressure and a piston-valve arranged to control with the admission-ports and the release-ports and having ends of equal area, the ends of the valve-chamber being in communication with the ends of the cylinder respectively beyond the release-ports and the cylinder, substantially as described.

A pneumatic hammer comprising a valve having cylindrical end portions of equal area and an intermediate groove, said hammer having ports communicating with the source of pressure and opening into the valve-chamber in position to be controlled by the front and rear ends of the valve respectively and having three ports opening into the valve-chamber in position to register with the groove in the valve, the end ports of said three communicating with the cylinder near the front and rear ends thereof respectively and being in position to be alternately closed by the ends of the valve, and the intermediate port being permanently open to the groove of the valve and to the atmosphere, and said hammer having ports opening into the respective ends of the valve-



chamber beyond the limit of movement of the valve and communicating with the cylinder nearer the ends thereof than the ports which communicate with the valve-groove, substantially as described.

747,817. AIR-BRAKE COUPLING. Rudolph W. Wilke, Auburn Park, and Mathias Bauer, South Englewood, Ill. Filed June 23, 1903. Serial No. 162,703.

An air-brake coupling comprising a casing having an air-outlet, a flexible gasket seated around said opening within said casing and having

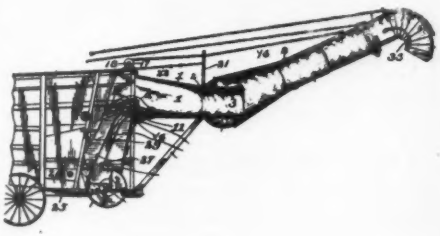
an annular flange projecting therefrom, a metal gasket seated on said flexible gasket, an annular flange on said metal gasket entering the opening in said flexible gasket to hold said metal gasket centered, a chamfered valve-seat in said metal gasket, an air-escape groove in said valve-seat, a removable cap mounted in the opposite wall of the coupling, projections on said cap bearing upon said metal gasket to hold same compressed on said flexible gasket, a central cylindrical chamber in said cap, a valve controlling the air-outlet and having a stem entering said chamber in said cap, a spring interposed between said cap and said valve for normally holding the latter on its seat, a projection at the other end of said valve projecting through the air-outlet, an enlarged head on said projection of smaller diameter than the air-outlet and a flat end and rounded edges on said head, said head projecting only slightly beyond the free end of the flange of the flexible washer and serving as a cam to be engaged by a similar head on the other coupling member when coupled therewith to open said valve, substantially as and for the purpose set forth.

747,987. PNEUMATIC CONVEYER ATTACHMENT FOR FEED-CUTTERS. Leo J. Lee, Stark, Wis. Filed June 9, 1903. Serial No. 160,771.

The combination of a feed-cutter, a fan-casing having closed end walls and with the discharge leading tangentially from one side and adapted to receive the material from the cutter tangentially at the opposite side, the fan-blades curved radially and adapted to receive the material upon their concave sides and discharge it from their convex sides, and an extension conveyer-spout rotatively connected to said discharge, substantially as specified.

747,896. PNEUMATIC STRAW-STACKER. Joseph K. Sharpe, Jr., Indianapolis, Ind., assignor to the Indiana Manufacturing Company, Indianapolis, Ind., a Corporation of West Virginia. Filed Sept. 28, 1901. Serial No. 76,876.

The combination, with a threshing-machine, of a pneumatic straw-stacker trunk or chute attached to and inclosing the rear upper portion thereof where it will receive the straw direct from the straw-floor of the separator, and a blast-fan located below said trunk or chute and provided with an



air-conduit leading therefrom and arranged to discharge into the rear end of the straw-stacker trunk or chute just above the substantially horizontal floor of the straw-chamber therein.

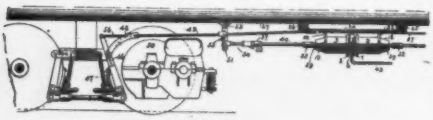
747,982. VALVE. John E. Kordick and Edward Sulgrove, Bridgewater, Iowa. Filed Sept. 5, 1903. Serial No. 172,084.

748,070. PNEUMATIC STACKER. John Henry, Grand Forks, N. D. Filed Mar. 6, 1902. Serial No. 96,984.

A pneumatic stacker, the combination with a straw-conveying tube and means for forcing a blast of air therethrough, of a straw-receiving chamber having a contracted portion communicating with the conveyer-tube and means for directing a blast of air from the side of said chamber toward the contracted outlet thereof.

748,192. VALVE. John Knowles, Colorado Springs, Colo. Filed Mar. 24, 1903. Serial No. 149,329.

748,302. DUPLEX AIR-BRAKE SYSTEM. William H. Nightingale, Philadelphia, Pa., assignor to John E. Reyburn, Philadelphia, Pa. Filed Dec. 8, 1902. Serial No. 134,224.



A brake, duplex cylinders having a separable central connection with means to attach each cylinder and the connection independently to the car, an air-passage to the connection, a partition in the passage and a port at each side of the partition leading into each of the duplex cylinders aforesaid.

748,405. APPARATUS FOR AERATING LIQUIDS. Kenneth S. Murray, Westminster, England. Filed Mar. 3, 1903. Serial No. 146,601.

748,498. AIR-PUMP. Martin E. Harmstead, Burlington, N. J., assignor of one-half to Joseph J. Sleeper, Philadelphia, Pa. Filed Oct. 29, 1901. Serial No. 80,408.

A device of the character described, a drum, a hollow axis therefor, a fluid partly filling the drum air-inlets, pipes communicating with the interior of the drum upon opposite sides of said fluid, aid means concentric with said shaft for forming communication alternately between one or the other of said pipes and the interior of said hollow shaft as the drum is oscillated in opposite directions whereby the direction of flow of the air is automatically controlled a[illegible]rsed.

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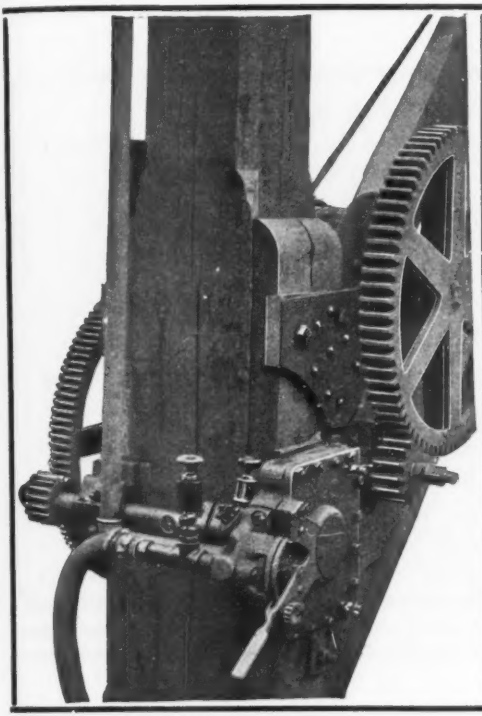

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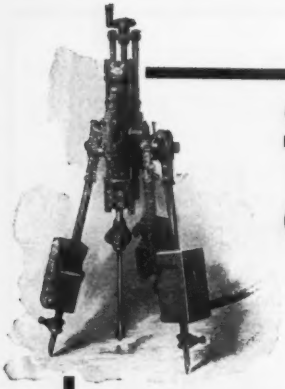

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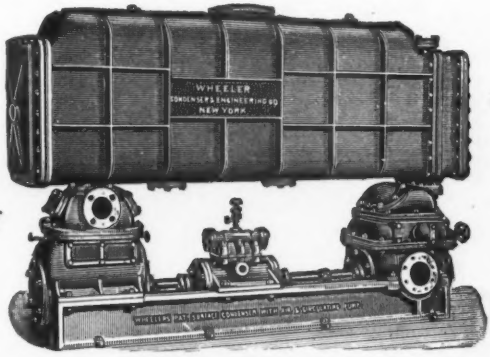

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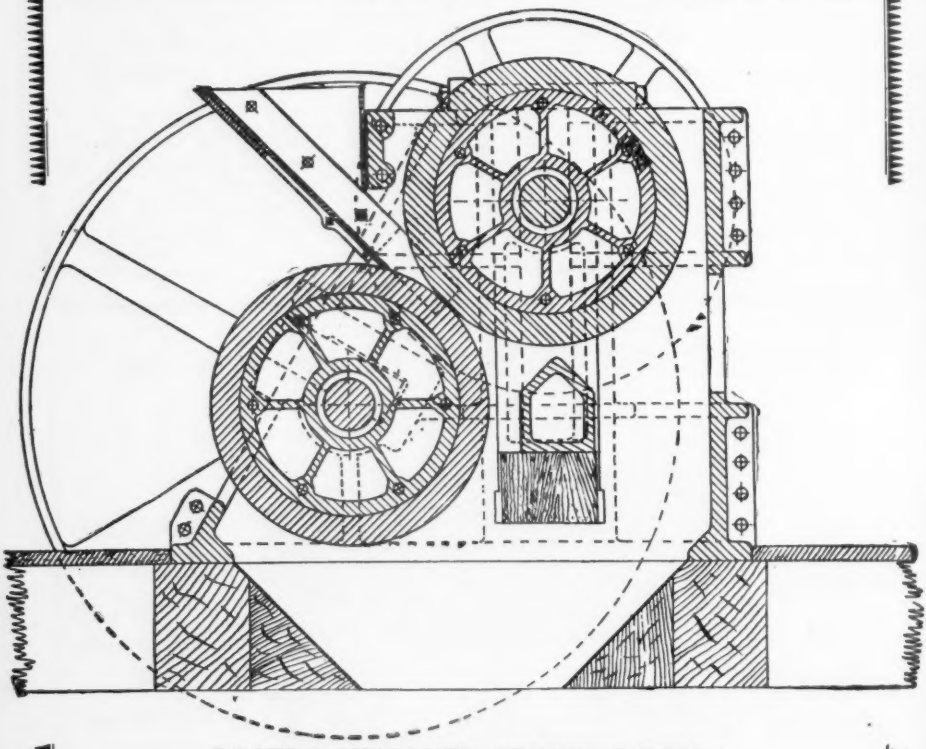

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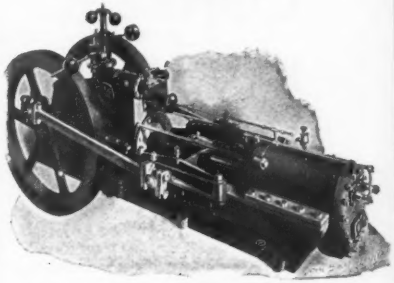

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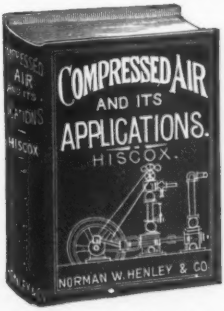

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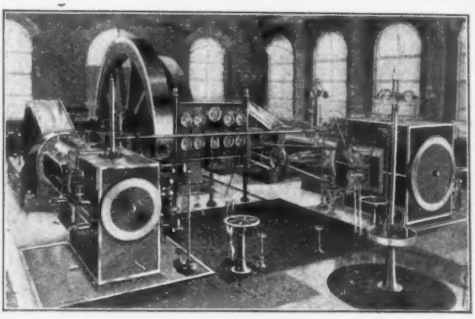

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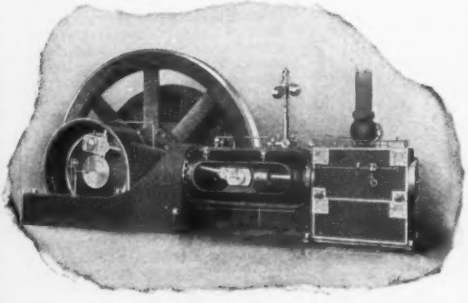

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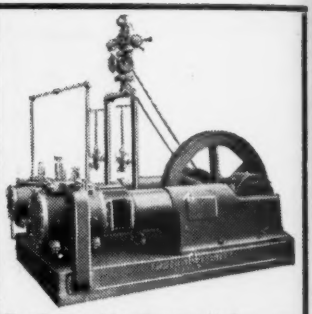

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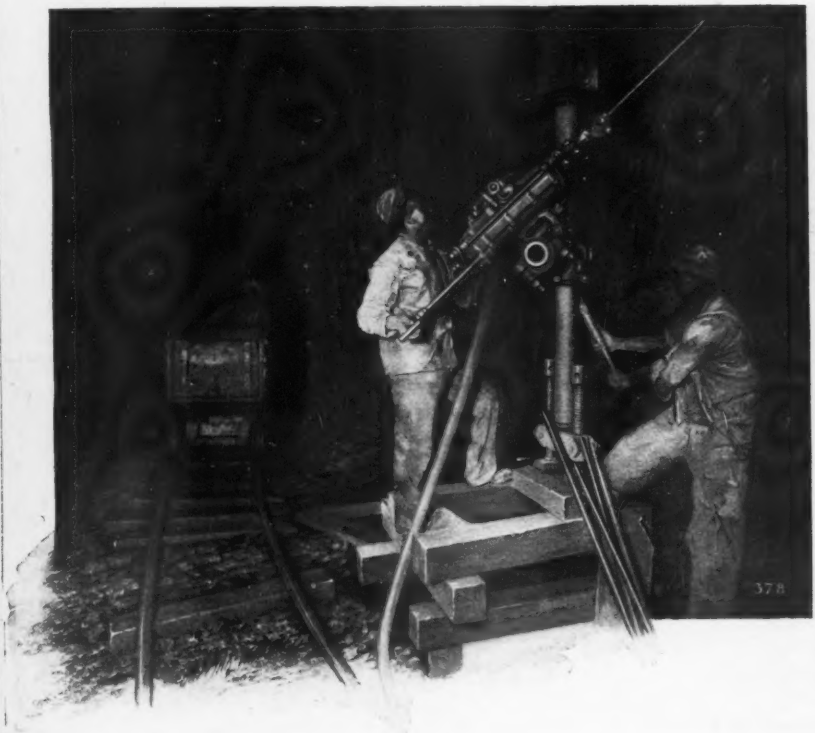

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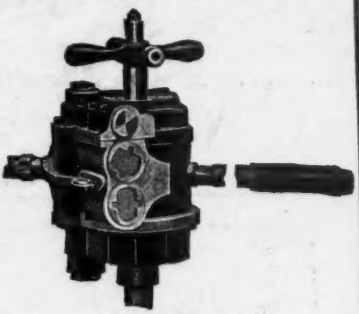

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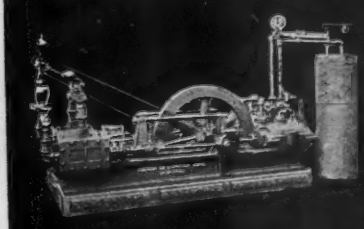

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